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PROCEEDINGS OF AN INVITATIONAL CONFERENCE ON JOB PERFORMANCE AID COST FACTORS

NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER, SAN DIEGO, CALIFORNIA

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An invitational conference, sponsored by the Navy Personnel Research and Development Center, was held on 2-3 June 1982. The purpose of the conference was to identify factors influencing job performance aid cost and to determine methods for measuring and predicting these factors. Three government (Army, Navy, and Air Force) and eight industrial (researchers and developers) representatives participated. This report gives

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each participant's presentation, a summary of the discussions following each presentation, an overall summary of the cost factors identified, and the conclusions regarding cost prediction.

FOREWORD

These proceedings are the result of an invitational conference on job performance aid (JPA) cost factors held in San Diego, California, 2-3 June 1982. The conference was sponsored by the Navy Personnel Research and Development Center and conducted as part of the enlisted personnel individualized career system (EPICS) program.

EPICS research and development is guided by Navy decision coordinating paper (NDCP) Z0820-PN (formerly titled Performance Aids Test and Evaluation) and is under the sponsorship of the Deputy Chief of Naval Operations for Manpower, Personnel, and Training (OP-01). The objectives of the NDCP are to define the state of the art in JPA technology, develop a conceptual model for an integrated JPA-based personnel system including cost benefits and tradeoff analysis, test the JPA concept, and quantify performance increments and cost benefits obtainable for various applications.

This report is the eighth in a series of studies dealing with JPA technology development: (1) NPRDC TR 77-33 included seven papers assessing the state of the art in JPA technology, (2) NPRDC TN 78-6 described a preliminary enlisted personnel system concept with major emphasis on the use of JPAs, (3) NPRDC TR 78-26 was a systematic review and organization of existing JPA techniques, related research data, and various applicable principles and concepts, (4) NPRDC TN 79-1 defined a JPA selection algorithm or an integrated personnel system, (5) NPRDC TR 79-25 discussed development of hybrid and enriched hybrid troubleshooting JPAs, (6) NPRDC TR 82-7 described the development and test of a troubleshooting aid for digital systems, and (7) NPRDC SR 83-32 described a field evaluation of enriched hybrid troubleshooting JPAs. The purpose of the conference was to bring together JPA researchers and developers to define the factors influencing JPA cost, the measurement and estimation of these factors, the weight of their influence, and the identification of potential guidelines for accurate cost estimation.

The presentations are essentially a verbatim transcript of each individual's remarks. Each presentation is followed by a discussion section that summarizes the comments by all participants during and after the individual's presentation. Abbreviations and acronyms are used throughout. Therefore, the attention of the reader is invited to the list of abbreviations and acronyms that follows the references.

JAMES F. KELLY, JR.
Commanding Officer

JAMES W. TWEEDDALE
Technical Director

SUMMARY

Background and Purpose

An invitational conference sponsored by the Navy Personnel Research and Development Center (NAVPERSRANDCEN) was held in San Diego, California during 2-3 June 1982. The purpose of the conference was to identify factors that influence job performance aid (JPA) cost and to discuss the measurement and prediction of these factors. Individuals were invited from three government and eight industry locations. Individual presentations were intermixed with group discussion and interaction. This report provides the content of the presentations, a summary of the discussion surrounding each presentation, and a summary of the cost factors and conclusions regarding cost prediction.

Introduction

The meeting was opened by Dr. Glenn Osga of Systems Exploration, Incorporated, who welcomed everyone, and Dr. Robert Blanchard of NAVPERSRANDCEN, who briefly discussed the context of the meeting as generating from the continuing enlisted personnel individualized career system (EPICS) research effort. He identified the existence of inadequacies in cost estimation and the importance of identifying cost within a cost-versus-effectiveness framework for different technical data presentation methods. Dr. Blanchard emphasized the use of an integrated personnel systems approach, suggesting that JPAs not be emphasized to the exclusion of other methods/considerations with overall cost impacts on personnel career development. Dr. Robert Smillie of NAVPERSRANDCEN followed Dr. Blanchard's comments with some general comments that served to focus the meetings. Dr. Smillie proposed a question for the meeting: Looking from the project director's point of view with user skill/job level and budget defined for technical data procurement, what are the cost factors and what are the cost effectiveness tradeoffs?

Presentations

In the first presentation, Mr. Don Finegan of the U.S. Army presented an overview of a cost and volume study being conducted by the Army for the purpose of improving skilled performance aid (SPA) specifications. Mr. Finegan outlined a number of cost drivers, including level of detail, illustration quantity, color vs. black and white, logistics support analysis requirements (LSAR) data use, and cost impacts of numerous presentation techniques and technical data development procedures. He concluded with suggestions for cost reduction such as using training people to write technical manuals and improving JPA specifications. During discussion, it was determined that procurement people must be trained to understand the flexibility contained in specifications and what is required by the government. Allowing a certain latitude in specifications is all right if the procurers are knowlegeable and effective.

Mr. Sam Rainey of the David Taylor Naval Ship Research and Development Center outlined major cost drivers from the Navy's perspective. He focused on the effectiveness of the system acquisition manager as a major cost determinant. Mr. Rainey pointed to inadequate input data in the form of poor logistics support analysis (LSA) and indicated that much technical material is done "just to get it in on time" with poor quality control. In the cost vs. quality decision, however, lower cost usually wins because upper management people do not recognize quality but do know when budgets are overrun. Mr. Rainey concluded, however, that cost must be viewed as secondary to effectiveness and never in isolation.

Mr. Ted Post of BioTechnology, Inc. discussed present methods of JPA production through the use of a master book plan from which a task identification matrix is formed. This leads to cost-per-page information based on labor rates, pages of illustration, etc. Mr. Post explained that, all too often, knowledge of this cost-estimation process resides with contractors, not contract monitors. Also, Mr. Post suggested that better use of historical data be implemented, such as done by Project Hardman, to determine technical data needs and costs before the design freeze stage. He stated that the user-data match is important and that JPA developers should be involved early in the procurement process to participate in tradeoff decisions.

Mr. Fred Hart of Kinton, Inc. discussed JPA cost factors for the development of procedural and functional JPAs. Procedural JPAs were discussed within a six-stage development process; and functional JPAs, within a variable stage process dependent upon the type of illustration/text used. Specific cost drivers were presented for each process step. Mr. Hart concluded that the procuring agency must know what the technical information needs are to complement a given system, and this information should not simply be a volume of data not addressing user needs. Lack of needs analysis during early development of a system was cited as a major problem contributing to procuring agencies' inefficiency.

Dr. Kay Inaba of Xyzyx Information Company placed cost considerations as the biggest contributing factor inhibiting the implementation of JPAs in the field because problems (and cost uncertainty) are anticipated in view of unsure production specifications. Dr. Inaba made a distinction between "front-end" analysis work and JPA generation work during his presentation. He felt that his company has been able to stabilize generation costs with computer-aided authoring. Major cost factors discussed were the quality of background technical data available as input, the inclusion/exclusion of troubleshooting tasks, and the production time necessary for translating ideas into sentences. Dr. Inaba discussed a computer program to aid sentence writing, his techniques for dealing with background data quality, and, finally, possible ways of reducing cost for troubleshooting tasks. Computerized text processing and storage were also suggested as cost reducers.

Mr. William Conroy of the Raytheon Service Company presented an example of the development of maintenance requirement cards (MRCs) with an estimate of man-hours for a given development project based upon local equipment availability and other specified personnel/background data states. He then compared actual hours used and presented specific reasons for prediction errors. Mr. Conroy questioned the overkill in manual procurement and the need for verification/validation using 100 percent of the procedures. He suggested that level of detail, amount of artwork, personnel safety required, and working environment factors combine to influence cost substantially by dictating quality/type of technical data necessary for the on-the-job user.

Ms. Rosemarie Preidis of the Air Force Human Resources Laboratory (AFHRL), presented data from an ongoing project that has resulted in the development of a computer algorithm designed to predict page quantity and type for technical manuals, given the number of subsystems, line replaceable units (LRUs), and shop replaceable units (SRUs). A regression equation that estimates 12 types of page quantities, given these inputs, was developed. She presented an example in which cost data from three contractor sources were inserted into the model to estimate total production costs.

Mr. Fran Rahl of Westinghouse Electric Corporation described cost factors as either JPA attributes or circumstances surrounding JPA development. JPA attributes described

were text/graphics mix, data density, and gross page volume. Development circumstances, such as customer type, competition, existence/availability of hardware, etc., were described as difficult to quantify, not apparent in the final product appearance, and influencing cost more than JPA characteristics. Mr. Rahl concluded that price models would be of most use in performing tradeoff analysis, as opposed to estimating final cost.

Mr. John Weber of the Lockheed-California Company presented contractor staff characteristics, project schedule, and overhead costs as primary factors affecting the quality and cost of JPA production. Mr. Weber explained how the request for quotation (RFQ) response-time schedule can undermine the competitive bidding system and affect quality and cost of the final product. Staffing problems in JPA production are difficult to control as a result of lack of continuity for JPA work and stringent training requirements for JPA writers. Company overhead rates were also seen as a major cost driver. Mr. Weber concluded that the labor-intensive JPA development process is most directly affected by the contractor in-house personnel system attributes and, to a lesser degree, by JPA attributes and formats.

Mr. Reid Joyce of Applied Science Associates reviewed conference presentations, discussed the "system acquisition manager problem" and emphasized the need to institutionalize changes in the procurement process related to JPA acquisition. Mr. Joyce presented a discussion of new positions that would be created as part of this institutional change. He feels that there are so many ways of getting around poor cost estimates that the motivation for accurate estimates must be legislated and driven by such institutional changes.

Mr. John Bean of the Hughes Aircraft Company compared two methods of cost estimation. The first estimated total cost as a function of historical similarity between new and previous systems combined with some function of the new system (like number of LRUs, SRUs, etc.). The second method used work elements such as writing, editing, photography, etc. combined with the system functions. Mr. Bean discussed the accuracy of each method, the key cost elements, and problems associated with utilizing "cost-per-page" in estimating project costs. He offered recommendations such as direct pickup of technical information source data, making an effort to keep technical information to an essential minimum, and inclusion of work samples as part of the request for proposal (RFP).

Dr. Glenn Osga of Systems Exploration, Incorporated summarized the presentations of the 11 speakers and grouped the salient points as cost factors, cost reduction suggestions, and cost estimation techniques. Dr. Osga presented these topics within a JPA development framework that comprises seven areas: (1) personnel, equipment, and environment characteristics, (2) procuring agency attributes, (3) JPA producer attributes, (4) JPA characteristics, (5) RFP/bidding processes, (6) input data quality, and (7) JPA production process. For each of these areas, the most important cost drivers are identified. Existing quantitative models need to be validated and expanded to include the myriad phases during JPA production with a separate focus on the front-end cost analysis. The front-end JPA development procedures and methods are so variable that accurate estimations of front-end costs cannot be made until responsibility for interim products is established. By reducing the variability in front-end preparation processes, historical cost data can be used to develop models such as the current AFHRL effort.

Recommendations

1. Identify areas where built-in test equipment (BITE) and automated test equipment (ATE) may be harmful to the troubleshooting technician as well as the cost tradeoffs for BITE and ATE.

2. Identify areas in the front-end analysis (e.g., the failure mode effects analysis and dependency analysis) that do not provide adequate troubleshooting data for development of troubleshooting JPAs.

3. Develop guidelines for JPA procurers that account for symmetry in electronic equipment.

4. Improve cost/effectiveness tradeoff guidelines for the user/data match.

5. Improve the methodology for quantifying the JPA cost impact elements.

6. Implement an education program for acquisition managers and procurement personnel that demonstrates the long-term life cycle cost effectiveness of the JPA methodology.

7. Develop criteria to reduce the variability of the attributes of procuring agencies.

8. Develop strategy that places the burden on the contractor for an accurate cost estimate.

9. Develop guidelines for including work samples in procurement packages.

10. Improve state-of-the-art methods for defining and quantifying cost-format-performance relationships.

11. Develop guidelines for establishing a bidders' conference that can be used to increase the understanding of requirements and clarify customer uncertainty.

12. Develop guidelines that adequately reflect the separation of front-end costs from JPA production costs.

13. Develop guidelines that delineate the responsibilities for quality input data for the JPA development process.

14. Determine the relationship of LSA to the JPA development process and identify the JPA input data gaps.

15. Establish cost-effective guidelines for JPA validation/verification that address task sample size, user sample size, and availability of equipment.

16. Identify specific areas where production specifications are forcing increased volume and cost, and develop guidelines for improving the process.

CONTENTS

INTRODUCTION

Dr. Glenn A. Osga
Systems Exploration, Incorporated
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Background

In an introduction to a previous conference on the status of job performance aid (JPA) technology, Blanchard (1977) noted the existance of piece-meal implementation of JPAs by the military services despite numerous studies suggesting positive reductions in training and maintenance costs. During the present conference, it was suggested that cost was the biggest single barrier impeding JPA implementation. When JPAs are thought of--high cost must follow. The validity of this statement may or may not be true, given that other methods of technical documentation are not inexpensive. Considering cost without considering effectiveness should not be done, at least in theory. We are not able to obtain very good measurements of effectiveness in performance terms, given the state of our methods and the real-world restrictions. Thus, cost is quite often a solitary consideration.

First, consider the estimation of cost for a technical data producing project. How is it done and what motivates the preparer to be accurate? Are high estimates due to fear of problems and unsure customer guidance? Are estimates better based on historical data or careful addition of cost elements for a current project?

Second, considering the high cost of technical data production, how can we reduce overall costs and, therefore, increase the likelihood of implementation? Can the customer decide what technical information format is most cost effective for his system or does he care? If he does care, how can the JPA community guide his decisions through carefully planned proposal and contract meetings? How does the customer compare proposals and what are the cost effects of poor background data collection or specification implementation? These varied questions surrounding the topic of JPA preparation cost provided the impetus to conduct this work group meeting.

Purpose

Consideration of these cost questions stems from ongoing efforts at the Navy Personnel Research and Development Center (NAVPERSRANDCEN) to increase the understanding of costing problems in JPA systems and, therefore, advance the state of the art with respect to their implementation. The information collected during these discussions could then provide a groundwork for attacking the cost problem at different fronts.

The thought behind the present conference was to provide an informal atmosphere where a group of government and contractor JPA specialists could voice their opinions about factors, situations, necessities, etc. that affect cost and cost estimation. First, it was hoped that cost-affecting processes, regulations, specifications, key personnel, methodologies, and various facts of life found within both government and industry settings would be identified. Second, it was anticipated that the government would present desires (or demands) to the contractors and vice versa. Third, and most important, it was hoped that information exchange would not stop with identification and statement of various desires, but that concrete recommendations for improving these problems might be voiced.

Approach

An informal approach was utilized in which participants were asked to prepare a short briefing on their experience in cost estimation and how they felt it could be better done with costs better controlled. Participants used notes but talked freely.

These proceedings present a synopsis of the oral and written information submitted at the 2-day meeting. Presentations varied greatly in the relative amount of discussion and presentation. Each participant's material is presented, followed by a synopsis of the discussion during/after the presentation. Synposis of discussion/presentations were prepared from various sources including conference notes, secretarial notes, taped conference proceedings, proceedings, and written materials submitted by presenters. Hopefully, they will provide guidance for further study of cost problems.

OPENING COMMENTS

Dr. Robert E. Blanchard and Dr. Robert J. Smillie
Navy Personnel Research and Development Center
San Diego, California

Dr. Blanchard

I would like to discuss the background behind this conference. Most of you are aware of the EPICS program, which has been conducted at NAVPERSRANDCEN during the previous 6 years. At the present time, we have developed what we feel are state-of-the-art JPAs, which have been implemented on 34 Navy ships over the past year and a half. An important part of the JPA methodology and of the EPICS program is development of methodology that can be used in future procurements. We hope to develop and extend the methodology that has evolved during the EPICS program and implement this in training, JPA, and job design projects, following thorough field testing. One of the things that we've discovered in trying to model this complex personnel system is that we're really not very adept at anticipating, forecasting, or modeling cost and incorporating cost tradeoffs with the other personnel factors. For example, a very straightforward type of tradeoff that we have considered is that between JPAs and training utilization. Although the use of JPAs over training is really the "battle cry" of the EPICS program, what we have done in fact is replace very expensive training programs with very expensive JPAs. One must consider, however, that trained personnel matriculate through the system and JPAs are with us to stay.

What we need, ladies and gentlemen, is some help in how to evaluate costs and cost modeling, and how these factors are related. I guess the only comment that I would offer is that you not get buried in JPA costing to the exclusion of other factors. At NAVPERSRANDCEN, we feel very strongly about integrated personnel system approaches to these problems. In other words, try not to get your eyes "too close to the table," as it may be, in considering just technical data. You will be concerned with these things during the course of this meeting. However, we are really interested in overall cost and cost impacts in things of this nature. Appreciate that we are after a model--something that we can implement in the personnel system and use to offer alternatives, options, tradeoffs in costing out these factors. Costs are extremely important in the world we deal with today. I'd like to wish you the best of luck during this conference and I hope the dialogue runs freely and that we really accomplish something.

Dr. Smillie

What we're really trying to get and to come up with at the end of this conference is a general direction, as opposed to definitive conclusions. I don't think we will be able to get everything laid out as far as what the cost factors are and how they interact. Assume, from a project director's point of view, that you are procuring technical documentation that has to accompany a specific system. Therefore, what kind of guidance can we give such a person when he knows (1) what his user audience is going to be, and (2) what his overall budget is for buying technical data? How does he decide what type of format to utilize for the JPA or what proportion of his dollars to sink into training vs. paper-type JPA products? We're not trying to get into specifically what Lockheed or Xyzyx charge when they are developing job performance aids. What we really are after is what components they consider when they make a bid on such a project. They know, for example, that a certain amount of illustrating hours will be necessary for the pictorial portions of the JPA and that these will be costly. With these comments in, we can get started on our first presentation.

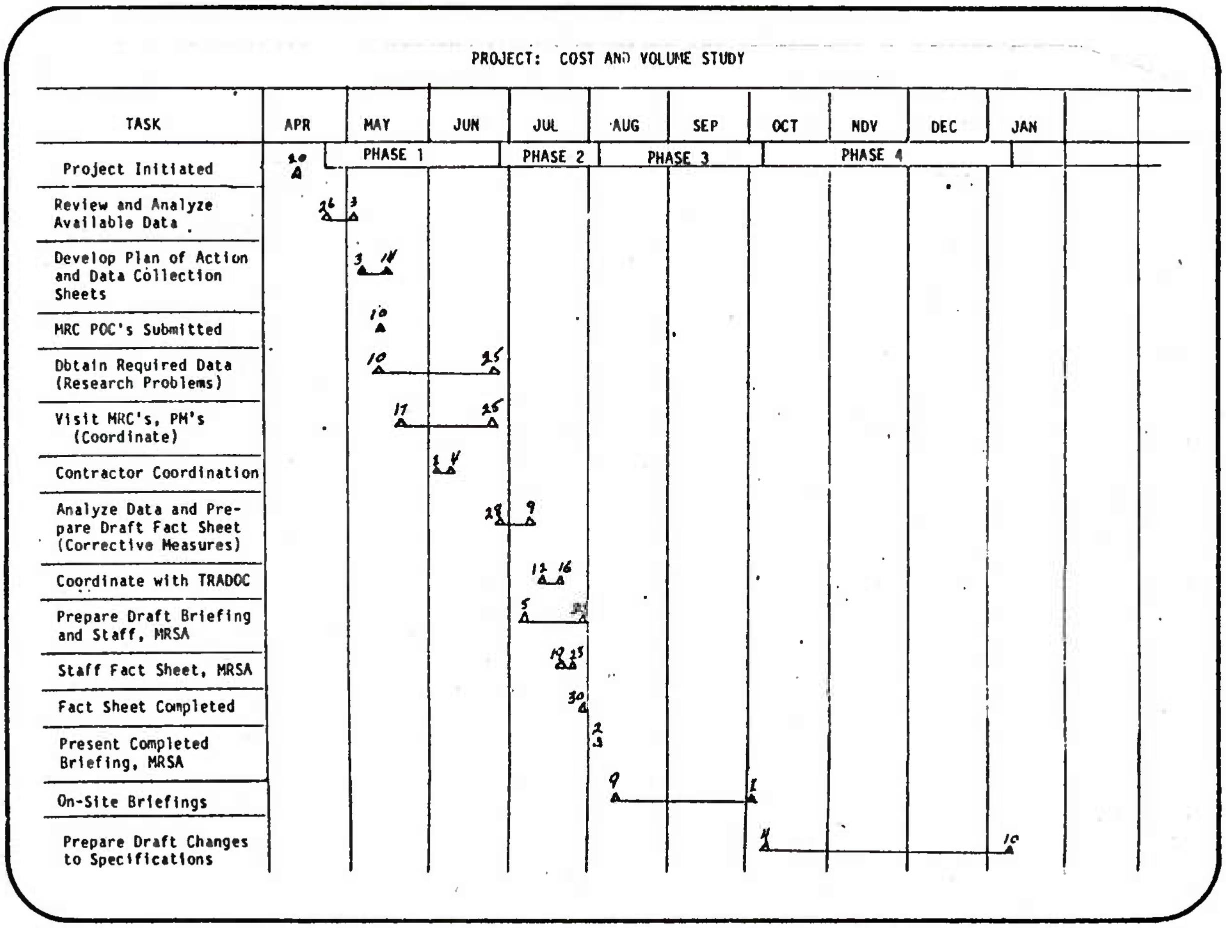
IMPROVING THE SPECIFICATIONS FOR SKILLED PERFORMANCE AIDS

Mr. Don Finegan
U.S. Army DARCOM-MERSA
Lexington, Kentucky

Presentation

I have brought an outline of a cost and volume study which the Army is currently conducting. The Army buys what are called "skilled performance aids," or SPAs, that are similar to job performance aids. I will present two slides concerned with this study. Specifically, this study covers two specifications that the Army uses to procure SPAs.

Slide 1 shows basically the time frame that we are looking at. We are at this point in time in the current project (refer to Item 25 on slide 1), and part of what I came here for is to obtain contractor input on what your cost drivers are. Also, what volume problems you have had in your experiences. Our experience has been that the specifications are often misinterpreted due to their great latitude with the effect of volume going up; we'd like to get some control over that situation.



Finegan: Slide 1

What we are going to do is to put together a package, coordinate with TRADOC, go out to the various commands, and brief them on this project. The packages that we present to them will probably contain elements which we will include in future contracts, until we can make the changes in the specifications. Since it will probably be some time until the specifications are changed, we hope that this package will serve as an interim guide for our contract monitors. Slide 2 shows the specific areas that we are investigating. An example of overkill would be six pages of text to inflate a tire. We are investigating the use of color in things like dependency charts and wiring diagrams.

AREAS BEING INVESTIGATED

- OVERKILL, I.E., TOO MUCH DETAIL FOR SIMPLE PROCEDURES.
- QUANTITY OF ILLUSTRATIONS - COST BENEFIT VERSUS INCREASE IN USABILITY FACTORS.
- GUIDELINES FOR USE OF COLOR AS RELATED TO COST/USABILITY FACTORS.
- USE OF LOGISTICS SUPPORT ANALYSIS RECORD (LSAR) DATA - COST IMPACT UPON PUBLICATIONS.
- INSTRUCTIONS FOR TAILORING SPECIFICATIONS.
- VALIDATION AND VERIFICATION COSTS (METHODS AND COSTS).
- SPECIFICATION REQUIREMENTS, ESPECIALLY THOSE CITING REQUIREMENTS FOR DETAIL STEP-BY-STEP PROCEDURES (REF. PAGES 6/2, 6/9, 6/10, 7/1, 7/2, AND 7/3 OF MIL-HDBK-63038-1.
- USE OF REFERENCES (CLARIFICATION).
- USE OF LOCATOR VIEWS AND HUMAN FIGURES.
- USE OF CURTAILED TEXT.
- COVERAGE FOR SYMMETRICALLY OPPOSITE HARDWARE AND LIKE ITEMS.
- COVERAGE OF MAINTENANCE PROCEDURES AS LOGICAL TASKS/JOBS RATHER THAN PIECEMEAL TYPE COVERAGE OF EVERY ITEM LISTED ON THE MAC.
- USE OF TABULAR PRESENTATION TECHNIQUES.

Finegan: Slide 2

The Army uses target audience personnel during their validation of JPA materials and this tends to increase cost. Regarding the use of references, when we went to integrated art and text, we did away with the reference of illustrations in the text. We do allow some limited use of illustration references in cases where the equipment is "torn down" prior to maintenance. But we have found in many cases that this is not utilized and procedures are described repeatedly throughout the text.

Regarding the use of locator views and human figures, we want to restrict the use of locator views to one per procedure. The use of curtailed text depends, of course, on the target audience. Basically, we hope to use illustrations, where possible, to show items, rather than lengthy textual descriptions. To sum up, these are the main areas that we are investigating right now. Any kind of input we can get from the contractor's side concerning specification improvements or factors that we haven't even considered would be appreciated.

Discussion

Initial discussion centered on the use of color in SPAs. Early specifications pushed the use of color in some of the procedural SPAs. Mr. Finegan said that a survey was under way to obtain subjective data on user opinion of color. Color has been shown to influence some types of information transfer positively and have no effect on others. Color use on wiring diagrams was discussed and opinions were mixed. Gray shading was suggested as a lower-cost (but still expensive) alternative. Color is often used at the whim of the individual buyer regardless of the specifications regulating the use of color.

Discussion then focused on specifications and in-process reviews. Lack of start-of-work meetings and improper in-process reviews were cited as significant cost drivers. These events are hampered by poor government specifications of the products it wants. The need for thorough government analysis and review of systems needs prior to the contractor involvement was emphasized. Mr. Finegan stated that this was the purpose of the "package" they hoped to create--to provide a checklist with examples of items that they (the customer) could utilize. Also, a need was voiced for follow-up on written specifications to ensure they are followed and understood by procurement specialists. The need for training to accompany the specifications was emphasized by participants. Benefit of latitude in specifications was discussed and the latitude is reduced when requirements are tailored to the individual project. It was agreed that this latitude is of benefit only when contact procurers were knowledgeable and effective.

Mr. Finegan mentioned the possible specification of a tabular format for maintenance procedures to restrict volume. Discussion of specifications ended with a brief dialogue concerning modified specifications and contractor training of writers for implementing specifications in their writing. Modified specifications were mentioned as easing writing jobs by reducing the redundancy of text; however, it was noted that these specifications also can overpower the writer with a large volume of information.

The use of logistic support analysis record (LSAR) data and the effect of use on cost was discussed. It was agreed that LSAR could be useful, but often was not, because it was not properly collected. Part of the problem lies in the endeavor of LSAR data to be everything to many different disciplines, while not specifically for technical manual developers.

Discussion of validation/verification was controversial concerning the effectivenss of these techniques and appropriate methodology for conducting them, and the feasibility and cost of utilizing 100 percent of the tasks involved. Target audience use was agreed to be necessary, but other topics were unresolved. Verification of troubleshooting procedures was discussed. The use of subject matter expert input for technical accuracy and target audience input for comprehensibility was suggested. Group consensus was that fault insertion was the generally used method of verifying troubleshooting; however, the method of selection/sampling of faults varied and was dependent on project management.

Discussion of task overlap centered on the problem of analyzing tasks and eliminating pages of overlapped information common to many different tasks. The group agreed that this analysis should be done early and that the contractor will generally not have the time or money to do this. A suggestion was made that an initial front-end analysis be done by the government to serve as a guideline for the project monitoring process. The use of the training people as writers could reduce task analysis and data overlap problems, but this would be more expensive than using conventional technical writers.

MAJOR TECHNICAL INFORMATION COST DRIVERS FROM THE NAVY'S PERSPECTIVE

Mr. Samuel C. Rainey
David Taylor Naval Ship Research and Development Center
Bethesda, Maryland 20084

Presentation

I said earlier that one of the biggest factors that affects technical information (TI) cost, at least in the Navy, stems from the systems acquisition managers themselves and, in particular, those in the Naval Sea Systems Command--which buys 90 percent of the Navy's documentation. An acquisition manager might spend large sums of money for TI--60 million dollars, for example--and be primarily concerned that he get the material delivered on time without equivalent concern for the quality of the material. It takes a lot of time just trying to get the attention of people like that and they are buying approximately 3000 manuals per year (with at least some form of TI for 100,000 pieces of equipment per year). In general, no one reviews those manuals--the quality control is negligible. So we sit at meetings like this trying to come up with solutions and suggest improvements in the TI generation processes, when the problem really seems to be implementation of these solutions once they are suggested.

How important is the TI cost in relation to consideration of TI effectiveness anyway? If I spend $1,000 per page and the equipment works and has less downtime, then that money is well spent. If I spend 50 percent of that amount and the TI is inadequate, I must have it done over again at higher cost. If I lost my equipment to downtime for a third of the time, then I've lost far more money in comparison (to the TI cost). Really, the only cost of major interest is the cost of system ownership. By that I mean dollars per hour that the equipment works.

My point is that system acquisition managers are not rewarded for buying good technical information. They are rewarded when they complete the purchase of a certain number of airplanes or hardware systems, regardless of the quality of the TI and other logistic support measures.

Also, inadequate integrated logistics support (ILS) and logistic support analysis (LSA) contribute to higher TI costs because the technical-manual generator has to repeat the analysis not done effectively in the first place before he can begin his job.

In the Navy technical information presentation program (NTIPP), we have often found that the engineering data base is formulated in such a way that, when it's handed over to the technical writers, it has to be extensively reworked. This is costly. Another cost driver is the need to implement certain comprehensibility approaches in the Navy under NTIPP. However, NTIPP-developed comprehensibility approaches will be accompanied by a good deal of automation, which will help keep the cost from rising further.

Discussion

Discussion of TI cost vs. effectiveness centered on participant disagreement as to the relative merit of the two factors. It was agreed that most often the persons who can make tradeoff decisions regarding cost vs. quality will make decisions that decrease cost, but produce a sacrifice in quality, because these top-level people do not inspect the products and would not know quality if they saw it. They do know when budgets are overrun, however.

Mr. Rainey identified two additional factors that he considered as contributing to increased TI cost:

1. The failure to integrate the needs of the training community into the initial TI preparation process, thus requiring that additional technical data be developed for use in the schools.

2. The incorporation of material into TI that cannot be used by the technicians, but which satisfies specifications.

The problem of updating TI when design changes are made was discussed. It was agreed that changes are often done informally by an engineer who typically expends much energy incorporating the design change with little motivation to spend any additional time and energy on updating manuals.

JPA COSTING TECHNIQUES

Mr. Theodore J. Post
BioTechnology, Inc.
Falls Church, Virginia

Presentation

To prepare for this conference, I ran a literature search on JPAs and cost. To my surprise, the search generated only a few documents (e.g., Booher, 1975; Chenzoff, 1973; Rowan, 1973; Defense Analysis Logistics Office, 1977). As you know, more documentation exists, but the reports tend not to find their way into the literature (e.g., presentations such as T. Braid's Life Cycle Cost Model,[1] or the Air Force's Initial Technical Order Project Findings[2]).

After this less than fruitful start, I chose to talk about the topic of JPA cost benefits, hopefully, in a way that is somewhat different from the usual treatment. I might note that my intent matches a point Bob Blanchard made in his opening remarks this morning; namely, that EPICS, the sponsor of this seminar, is seeking tradeoffs relative to JPA costs, not necessarily the nuts and bolts of costing.

My talk will include the three major topics shown in the first slide. Regarding the first topic (What do we have now?), I'll be brief because we'll probably be talking a lot about it over the next 2 days. On the second topic (What's wrong with what we have?), I'll point out the costing technique shortcomings which I believe are restraining JPAs from becoming a more effective system development tool. The third topic (What do we need?) is actually included as part of the second topic.

TOPICS TO BE COVERED

- What do we have now?
- What's wrong with what we have?
- What do we need?

Post: Slide 1

What Do We Have Now?

The second slide shows two of the main characteristics of the costing technique in current use. Two examples of the page-dependent characteristic are shown in Slides 3 and 4. Slide 3 represents the book plan for part of the system hardware in this example, the channel subsystem. The left column of the slide shows subtitles pertinent to the

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[1]Personnel communication.

[2]Project cancelled, only drafts were available.

hardware; the headers show the different types of pages which can appear in a book or technical manual (TM). The cell entries represent an expert's estimate pages, by type, for each subtitle. Sums by column appear at the foot of the matrix.[3]

WHAT DO WE HAVE NOW?

- Page-dependent
  - Bookplan type
  - Personnel resource type
- System-specific input
  - LSA products, i.e., TIM
  - User-task products, i.e., NTIPS

Post: Slide 2

The page counts for the book plans of each hardware item or maintainable unit are summed in order to prepare a master book plan illustrated in Slide 4. Header titles do not change, but the left column now contains the names of the maintainable units rather than the names of the sections which make up a maintainable unit's documentation. Again, sums appear at the foot of each column with one of the columns showing a grand total (i.e., 359 pages). At this point, the person preparing the cost estimates, usually a contractor's employee, relies on his organization's experience and records to develop cost estimates. These estimates are usually in terms of costs per page type and are labor dependent (e.g., the hours and pay rates of the personnel involved).

Where did the estimator get the information that appeared on the book plans (e.g., the maintainable units, the section titles)? Whether the item being costed is a conventional TM or a set of JPAs, the inputs normally come from the logistic support analysis (LSA). The top of Slide 5 represents the topdown breakdown prepared by LSA (Slide 6 presents part of a more realistic presentation of a breakdown). The topdown breakdown serves as one dimension of the task identification matrix (TIM) that LSA delivers to the TM/JPA organization (see the mid-portion of Slide 5). The second dimension of the TIM consists of generic functions (or descriptive information) that could be performed by system operators and technicians (see the lower part of Slide 5). The result of associating a generic function with a hardware item is a task. The center portion of Slide 5 represents the association of these to dimensions to form system tasks. LSA determines the task required to operate and maintain a system and documents its finding in the form of a TIM provided to the TM/JPA organization.

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[3] This bookplan was prepared for a TM revision effort. The parenthetical numbers represent the page count for the original TM version.

CHANNEL SUB-SYSTEMS

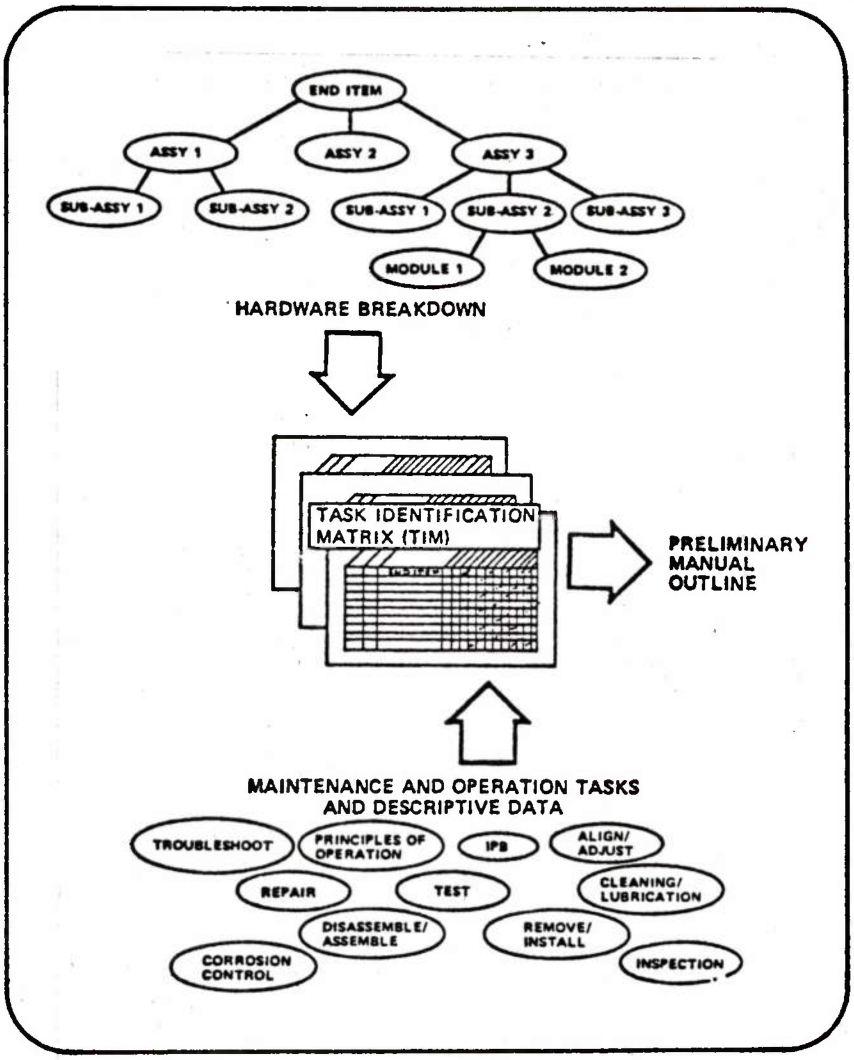
Section Name	Total Sheets	Single Sheet: Text	Single Sheet: Text/Line Draw	Single Sheet: Line Draw	Single Sheet: Half-Tone	Double Sheet: Line Draw	Triple Sheet: Line Draw	Quad Sheet: Line Draw	Comments
TABLE OF CONTENTS	1	1							New item per test 5-Package Content and Format.
PICTORIAL LOCATOR	1			1					Line drawing replacement of photograph per test 5-Package Content and Format.
TOPDOWN BREAKDOWN	1			1					New item per test 5-Package Content and Format.
OPERATING PRINCIPLES									Consolidated per test 4-Consolidation Check
General	1(1)		1(1)						
Conversion	1(1)		1(1)						
Synchronization	1(1)		1(1)						
Pulse Generation	1(1)		1(1)						
Symbol Forming	1(1)		1(1)						
TROUBLESHOOTING									Reorganization of material per test 5-Package Content and Format. Minor schematic revision per test 10-Troubleshooting Procedures Need for off-board components.
"□" Channel Diagram	4(4)							1(1)	
"+" Channel Diagram	4(4)							1(1)	
"H" Channel Diagram	4(4)							1(1)	
									( ) indicates original number of pages
MAINTAINABLE UNIT SUMMARY	20(17)	1	5(2)	2				3(3)	

Post: Slide 3

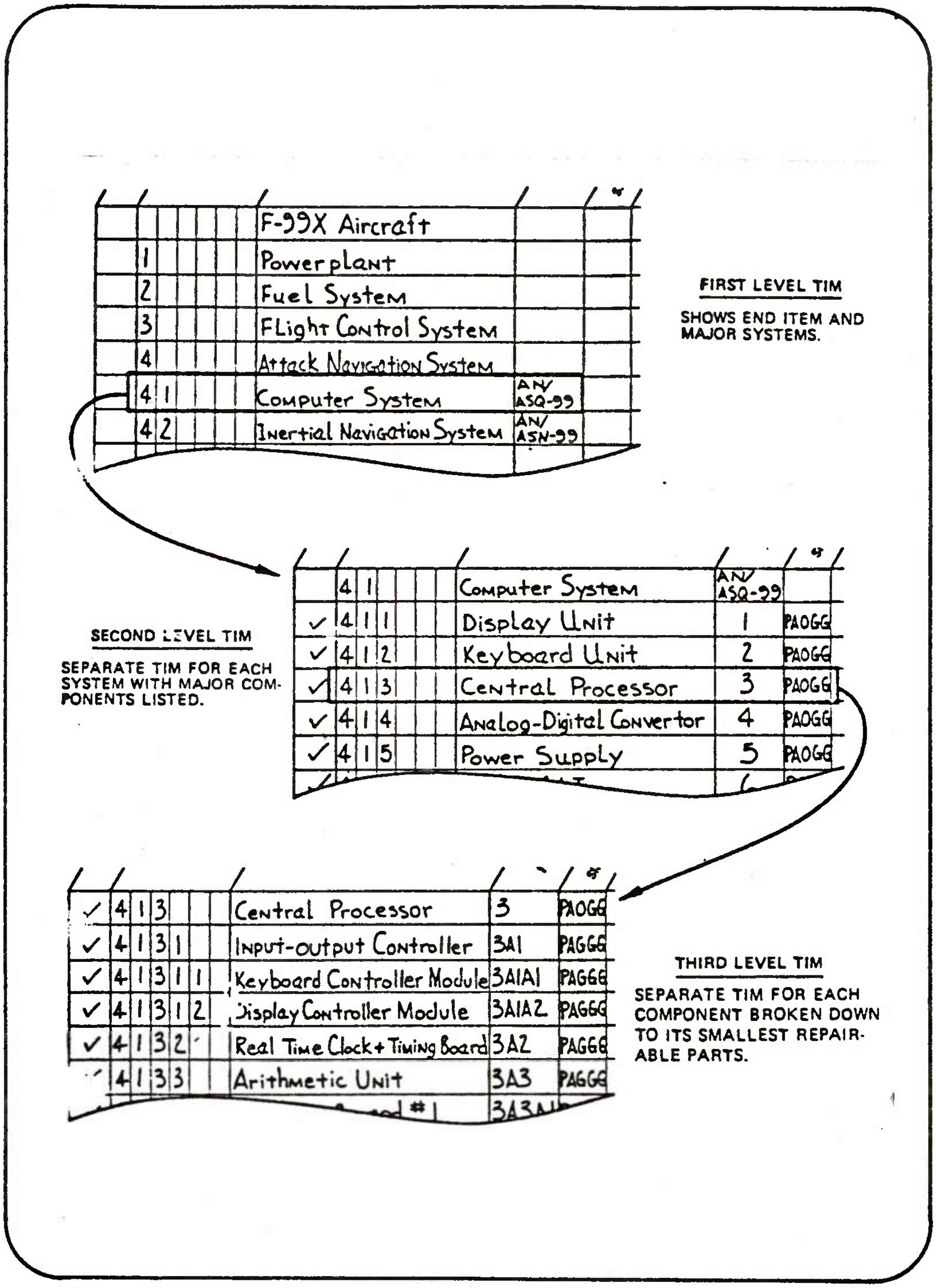
Master Book Plan

Maintainable Unit	Total Sheets	Single Sheet: Text	Single Sheet: Text/Line Draw	Single Sheet: Line Draw	Single Sheet: Half-Tone	Double Sheet: Line Draw	Triple Sheet: Line Draw	Quad Sheet: Line Draw
Signal Data Converter Unit System: AN/WSA-1C	76(73)	40(38)	14(14)	15(7)	(7)	2(2)	1(1)	
Power Supply	18(13)	5(3)	2(2)	7(2)	(2)			1(1)
Power Supply No. 1	8(7)	3(2)	1(1)	2	(2)	1(1)		
Power Supply No. 2	9(8)	3(1)	2(2)	2	(2)	1(1)		
Differential Servo Unit	14(11)	5(5)	4(3)	1	(3)	2		
Ramp Generator	19(20)	11(10)	3(4)	2(1)	(2)		1(1)	
Range Switching	11(11)	3(2)	4(5)	4(2)	(2)			
Video-Mixer Amplifier	10(10)	5(3)	2(4)	3(1)	(2)			
Control Indicator C-3247/WSA-1	6(6)	2(1)	1	1	(2)	1	(1)	
Monitor No. 1	13(14)	6(5)	3(4)	2(1)	(2)	1(1)		
Monitor No. 2	11(13)	5(3)	2(4)	2(2)	(2)	1(1)		
Monitor No. 3	13(15)	6(5)	3(5)	2(1)	(2)	1(1)		
Miscellaneous: Cabinet Assembly, Wiring Diagrams, Test Card	39(38)	13(12)		3	(3)		5(5)	2(2)
Channel Sub-systems	10(17)	1	5(5)	2				3(3)
Control Indicator C-3248/WSA-1	6(6)	2(1)	1	1	(2)	1	(1)	
Azimuth Servo Loop	15(11)	4(4)	6(4)	1	(3)	2		
Azimuth Mark Generator	11(11)	4(2)	4(6)	3(1)	(2)			
Servo Amplifier	9(8)	4(2)	2(3)	3(1)	(4)			
Range Servo Loop	16(12)	6(6)	5(3)	1	(3)	2		
Range Pulse Generator	17(16)	9(6)	3(5)	2	(2)		1(1)	
Range Interval Generator and Mixer	18(19)	9(7)	4(6)	2(2)	(2)	(1)	1	
( ) indicates original number of pages								
T O T A L S	359(331)	146(119)	71(80)	61(21)	(49)	15(8)	9(10)	6(6)

Post: Slide 4


END ITEM
ASSY 1
ASSY 2
ASSY 3
SUB-ASSY 1
SUB-ASSY 2
SUB-ASSY 1
SUB-ASSY 2
SUB-ASSY 3
MODULE 1
MODULE 2
HARDWARE BREAKDOWN
TASK IDENTIFICATION MATRIX (TIM)
PRELIMINARY MANUAL OUTLINE
MAINTENANCE AND OPERATION TASKS AND DESCRIPTIVE DATA
TROUBLESHOOT
PRINCIPLES OF OPERATION
IPB
ALIGN/ ADJUST
REPAIR
TEST
CLEANING/ LUBRICATION
DISASSEMBLE/ ASSEMBLE
REMOVE/ INSTALL
CORROSION CONTROL
INSPECTION

Post: Slide 5



Post: Slide 6

The user-TI match represents another system-specific input that is different from the book plan and TIM approaches. Developed as part of the Navy technical information presentation system (NTIPS), the match uses characteristics of the user, his task, and the task performance environment to define the types of TI required. This TI definition includes content, format, and style, as well as delivery medium (e.g., paper, CRT). The bases for the nonmedium definitions include user aptitude, training, experience, and number of users. The source data for these bases, for the most part, are the letter sheets

(e.g., D Sheets) developed by the LSA portion of the integrated logistics support (ILS) program.

Regardless of which approach is used to plan the TM/JPA effort, the bottom line is usually page-dependent and based on cost estimates prepared by experts. Slide 7 shows some page-dependent cost data developed by the USAF. The left column of the table lists the various types of JPAs or the elements of a TM. The column heads list the labor types (and hourly rates) involved in preparing information products. The body of the table indicates the hours and costs related to each cell; for example, the writer cost estimate for one page of job guide text is $47.50 (5 hours at $9.50 per hour). Totals for all labor and material cost estimates appear at the far right (e.g., the text portion of a single job guide page is estimated to cost $71.52).

Page Type / Cost Area	Writer @9.50	Editor @7.40	Illustrator @6.60	Typist @4.90	Proof Reader @4.60	Parts Catalog @6.60	Production @6.10	Q/A @6.10	Supervisory @11.80	Total Material	Total Hours DL & Mat $
Job Guide Text Note 1	5.0 47.50	1.0 7.40	0.1 .66	0.7 3.43	0.25 1.15	See Note 2	0.5 3.05	0.1 .61	0.4 4.72	5.00	8.05 71.52
Job Guide Illustration (no repeats)			8.0 52.80	See Note 3					0.7 8.26	5.00	15.3 124.82
Job Guide Illustration (repeats)			3.0 19.80						0.5 5.90	7.00	10.1 81.26
Fault Description Chart	12.0 114.00	1.0 7.40	4.0 26.40	1.5 6.75			0.7 4.27	0.5 3.05	1.0 11.80	3.00	20.7 176.67
FR/FI 1 Access Line Art	7.0 66.50		16.0 105.60	See Note 8					1.2 16.16	43.00	26.4 248.96
Fault Isolation (FI) Chart	12.0 114.00		4.0 26.40	1.5 6.75	See Note 10				1.0 11.80	7.00	20.7 176.67
FI System Schematic/ Block Diagram	9.5 90.25		16.0 105.60	See Note 9					1.4 16.52	8.80	29.1 236.56
FI System Schematic/ Flow Diagram			24.0 158.40						1.8 21.24	8.50	37.6 283.11
FI System Schematic Mech Diagram			32.0 211.20						2.5 29.5	8.50	46.2 364.17
FI System Schematic/ Hydraulic										8.50	46.2 364.17
FR/FI 2 Access Line Art	7.0 66.50			See Note 8						3.00	61.7 524.02
Intermediate/ Depot Text	9.5 90.25	1.0 7.40	0.15 .99	1.5 7.35	0.5 2.30	See Note 4	1.25 7.63	0.5 3.05	0.7 8.26	3.00	16.1 130.23
Intermediate/ Depot Tabular (I/D)	9.5 90.25		0.5 3.30	3.0 14.70	0.5 2.30	See Note 4	1.25 7.63		0.8 9.44	3.00	17.05 141.07
I/D Half Tone Art	3.0 28.50		6.0 39.60				0.7 4.27		0.5 5.90	15.00	10.7 103.27
I/D Half Tone Explosion	7.0 66.50		10.0 66.00				0.7 4.27		0.9 10.62	15.00	19.1 172.04

COST–DIRECT LABOR DATA – SOURCE I

Post: Slide 7

What's Wrong with What We've Got? (Slide 8)

The current costing practices have been criticized on several counts; for example, the process is unilaterial in that the expertise required to prepare cost estimates resides primarily with the contractors.[4] However, the criticism I have does not relate to the nuts and bolts of cost estimating. (I think it's pretty good--especially the approach being developed by the USAF.) My concern relates more to the bases for determining the types of JPAs for which we're preparing cost estimates. Specifically, our present cost estimates are based on inputs we receive from the LSA portion of the ILS program (if it is performed), and from inputs we receive from the acquisition manager in the form of specifications. In the former case, tradeoffs regarding manpower, personnel, and training are supposed to have been performed with the results reported on the LSA's lettered data sheets. We all know that, even if they are performed (and frequently they are not), the tradeoffs seldom include JPAs as an active element.

WHAT'S WRONG WITH WHAT WE'VE GOT?

- Subsystem Optimization
  - JPA experts are not represented in early trade studies
  - JPA developer keys on personnel demands of the system under development with insufficient attention to the Navy's personnel resources.

Post: Slide 8

What Do We Need?

With the benefit of hindsight, I will attempt to illustrate the types of involvement I believe JPA developers should have in the early portions of systems analysis. These involvements can occur as a result of adding new expertise to the ILS/LSA teams or they can occur as independent analyses (e.g., the Hardman Project[5] efforts which would also need expertise modification since the process does not now include TMs or JPAs).

Personnel Trades. The process and methods used to generate manpower, personnel, and training needs are biased in the direction of demands made by the system under development. These demands are documented and made available to JPA developers (among others). In the NTIPS world, these demands will be translated into TI requirements via methods such as the user-TI match. The problem I see is that insufficient attention (sometimes none) is paid to whether the manpower, personnel, and training

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[4]Initial Technical Order Project Findings, The Air Force Logistics Management Center, 1970, p. 32, 33.

[5]Hardman methodology handbook, Volume 1: Executive summary (preliminary draft). Washington, DC: Office of the Chief of Naval Operations, November 1980.

resources of the involved military are sufficient to meet these demands. All too often, new systems have been fielded only to discover that the levels of training and experience that TI developers were told to assume are far less than expected. TI development efforts, such as the user-TI match and validation and verification, will not detect and correct these faults because they too are based on what the system demands rather than what the military can provide. Users in the field and development managers criticize the symptoms rather than the causes (e.g., claims that the TMs or JPAs are inadequate seldom consider the source data available to TM or JPA developers).

My recommendation to relieve this problem is to have JPA developers involve themselves in the tradeoffs that should occur in the early analyses of system development. There are those who claim that we don't have the knowledge to perform these types of tradeoffs. I agree that we don't know as much as we'd like to know, but we are gaining on the problem with projects such as the USAF series on training and JPA tradeoffs (e.g., HASTY-TASTY) and the EPICS program that is sponsoring this seminar.

Logistic Trades. ILS personnel perform a second type of trade, again very often without the benefit of TM or JPA involvement. This trade concerns automated test, both on-line and off-line. Early automated test equipment (ATE) applications (those referred to as Turnkey versions) went to the field supported by technicians or operators who were expected only to be able to turn the ATE on and off and, if a failure was detected, to perform simple remove and replace actions in order to return the system to an up status. The technician's job was scaled down in terms of workload (number of personnel) and complexity (skill level, training, and TM needs). The military promptly met these scaled-down requirements. Unfortunately, field experience with Turnkey ATEs showed that the trades failed to account for a variety of technician responsibilities including the following: ATE covers only a part of the hardware and man must cover the remainder, ATE works accurately only part of the time (sometimes a depressingly small part of the time), and man must have the resources and skills to back up the ATE. Because the trades did not anticipate these main responsibilities, technicians were not available in sufficient numbers nor with the necessary skills, knowledges, and resources (including JPAs as well as test equipment) to perform these functions. Relatively large orders for additional TMs were among the "get well" efforts necessary to correct these Turnkey problems.

Again, my solution is to involve human factors and JPA interests in the early trades which relate to man's responsibilities. In the case of the Turnkey ATE, this involvement would include two phases. The first phase involves an analysis to allocate functions to man and machine. Such an analysis performed by human factors representatives will identify the detection-isolation tasks (e.g., from the TIM) for which operators and technicians have full responsibility, as well as the detection-isolation tasks for which technicians will backup the ATE. The product of the first phase is developed by translating these task responsibilities into manpower, training, and JPA needs (e.g., the demands the system under development places on the personnel system). The second phase of the recommended involvement is the discrepancy analysis referred to under the personnel trades discussion (e.g., analysts, including JPA experts, must reconcile any differences between the personnel demands made by the system under development and the personnel resources of the military). Early involvement of JPA experts in such personnel system trades (e.g., use of fully proceduralized JPAs) could well have captured the benefits of reduced skill level sought unsuccessfully by the planners of Turnkey ATE.

Benefits and Recommendations

I believe the benefits (Slide 9) of involving JPA expertise early in system analyses are as follows.

BENEFITS OF JPA EXPERTISE IN
EARLY SYSTEM TRADES

- JPA Visibility
- Corporate Memory
- JPA Cost Perspective

Post: Slide 9

Higher Visibility. At present, system acquisition managers tend to view JPAs (and technical manuals) as necessary evils, costly products that come along after early trade studies have solved all the real problems. Changing this attitude will require demonstrations to show that JPA expertise can be a contributing element of early trade studies.

Corporate Memory. The doctrine is largely in place for early trade studies, but TMs and JPAs are not a prominent aspect of these efforts. There is no repository for the results of relevent studies, no organization to translate evaluation results (such as EPICS) into trade practices, and no organization to advocate JPAs as an element of early trade studies.

Perspective of JPA Costs. The cost estimating practices being applied and developed within the JPA commuity appear adequate. However, in my opinion, we are not posing the cost question in the proper perspective when we ask, "How much will it cost to produce x number of y type JPAs?" The larger and more impressive issue should be, "Can a system acquisition manager use JPAs to bridge the gap betwen his system's personnel demands and the Navy's personnel resources?"

Discussion

Mr. Post suggested that the JPA community follow a Project Hardman type of approach. It was suggested that proper ILS analysis would do what Mr. Post was proposing and that Hardman was a "fix-it" approach to poor ILS work. The group agreed, however, that ILS was usually not done properly. A suggestion was made that Hardman could be utilized as a technique to improve ILS, especially in the area of tradeoff analysis.

Problems with ILS were discussed in terms of costs for LSA. It was noted that acquisition managers often feel that much of the data generated is not useful. The group agreed that we are "locked-into" an ILS framework. Further discussion centered on the problem of measuring actual performance as a criterion for technical information quality. Inadequacies with secondary criteria, such as text readability, were discussed and the group agreed that recent specifications requiring validation with a target population would increase the quality of the end product.

COST IMPACT OF JPA DEVELOPMENT PROCESS

Mr. Fred L. Hart
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Presentation

In my approach to looking at JPA costs, I decided to voice them under the context of the process through which JPAs are developed. I chose to take a look at those activities, and what the cost impacts of those activities are.

I think the acquisition manager doesn't necessarily have to specify the process by which the JPAs are developed, but he should know the factors that affect costs of this process. One of the things that occurred to me when we were talking this morning is that you need to have the acquisition manager know what elements are involved in the manuals. He needs to know how these elements are used. We talk about the development of these things and we talk about type of text and the format and the number of pages. We might want to look at it in a more general context from the standpoint: Do we need theory in the manual and, if so, why--what would be the use for it?

Considering the tasks, steps, and graphics in a JPA--how much graphics is necessary? To what level are you going to develop your JPAs? To what level do you want to define your task? This has a very significant effect on the cost of developing these products.

Another big question is whether or not the system exists. It is much easier to develop tasks on an existing system. On a nonexisting system, at what point in the development process does the technical information procured come into play?

In looking at the steps in the development of JPAs, I want to separate JPAs into two categories: straight procedural JPAs and what I call functional JPAs. In the functional area, I include troubleshooting aids.

In the procedural JPA area, I consider straightforward remove-and-replace maintenance types of tasks. The first step involved is identifying the tasks. Again, if you're going to develop a specification, I'm not so sure you're very concerned with how that identification occurs. However, when the process is done, you still need to know that 90 to 95 percent of the tasks have been identified. At this point, you have to consider your audience and which tasks you are going to train and which you are going to devote to on-the-job training. For the "first-cut" task analysis, my experience has been that you are going to use existing documentation. The system doesn't necessarily need to exist at this point, except that engineering drawings must be available.

The second step of this task analysis, which I think is extremely important, is the tryout of the procedures on the equipment. First of all, the availability of the equipment is a problem and, second, even if the equipment is available, "Are they going to let you touch it or take it apart to verify your procedures?" It has always been my experience that, at this point, there is not enough communication between the documentation and engineering departments. The documentation people have to get close to the engineering people to convince them that you can help them do their job, especially in cases where identification of a procedure finds some fault or problem with the equipment.

When I talk about validation, I mean validation on the actual equipment with a target audience. I think, from a cost effective standpoint, you may want to try a sampling

procedure in selecting your tasks. The bottom line at this point is: The procedure has got to work. Again, the procuring activity should look at the most economical way of doing validation.

The procuring agency has to define precisely what they want in their documentation. They should also know the cost impact of each of these items.

<u>JPA Cost Elements Identified Through JPA Development Process</u>

I. Introduction.

A. Procurement involves two types of JPAs.

1. Procedural.
2. Functional.

B. Costs are significantly different.

1. When systems exist.
2. On new systems.

II. Procedural JPA Cost Element.

A. Steps in process.

1. ID tasks.

a. Tied to maintenance philosophy.
b. Must identify all tasks (95-99%?).

2. First-cut task analysis.

a. Uses existing documentation.
b. Engineering drawings, etc.
c. Identifies as many steps as possible.
d. Identify graphics to extent possible.

3. Tryout on equipment.

a. Identifies all steps.
b. Establish all graphics.

4. Draft procedure for validation.

a. All steps with graphics.
b. In final format.

5. Validation.

a. On equipment.
b. Requirement for number of subjects.

6. Final preparation.

   a. Incorporated changes.
   b. Prepare camera-ready copy.
   b. Print.

B. Cost effects in each step of the process.

   1. Identify tasks.

      a. New equipment.
      b. Existing equipment.
      c. Formality of documentation to ensure completeness.

   2. First-cut task analysis.

      a. Existing equipment.

         (1) Quality of documentation.
         (2) Completeness.
         (3) Availability of equipment.

      b. New equipment.

         (1) Availability of documentation.
         (2) Availability of SMEs.
         (3) Availability of equipment.

   3. Tryout on equipment.

      a. Availability of equipment.
      b. Environment for photographs.
      c. Availability and use of target population.

   4. Draft procedure for validation.

      a. Virtually no external constraints.
      b. In-house production staff.
      c. Good time for IPR.

   5. Validation.

      a. Availability of equipment.
      b. Availability of target population.
      c. Number population used to validate.
      d. Sample versus total validation.

   6. Final preparation.

      a. Again internal to contractor.
      b. Function of production system.
      c. Camera-ready copy requirements.
      d. Printing.
      e. Printing requirements.

III. Functional JPA Cost Elements.

A. Element of functional JPAs.

1. Block diagrams/associated text.

a. Top-down breakdown.
b. Complete traceability from level to level.
c. Complete interconnection information.
d. Text for each functional block at each level.

2. Schematics/associated text.

a. Only for repairable assemblies.
b. Redrawn for functional layout.
c. Text for each functional grouping.

3. Troubleshooting aids.

a. Big area.

(1) Sympton/cause tables at all levels of system on down.
(2) Tree charts procedures.
(3) State tables.
(4) Fully proceduralized.
(5) Dependency charts.
(6) Built-in tests.
(7) Computer diagnostics.

b. Aids to be used must be precisely defined.

B. Steps in process.

1. Schematic preparation.

a. Schematic layout by writer.
b. Art department prepares.
c. Writer prepares text.

2. Block diagram preparation.

a. System functional analysis for top-down breakdown (used for both theory and troubleshooting).
b. Each block laid out by writer.
c. Art department prepared.
d. Writer prepares text.

3. Troubleshooting aids.

a. Varies with each type.
b. Great deal of analyses.

c. Requires art support.
d. May require some preparation as procedural JPAs along with analyses.

C. Cost effects of functional JPA processes.

1. Schematic preparation.

a. Requires engineering drawings.
b. Access to SME.
c. Process used to prepare art.

(1) By hand.
(2) Computer-aided.

d. Number of schematics to prepare.

2. Block diagram preparation.

a. Requires complete set of interconnection data.

b. Time to perform functional analysis obviously increases with increase in system size.

c. Access to SMEs.
d. Access to equipment.
e. Process used to prepare art.

3. Troubleshooting aids.

a. Access to test equipment to be used.
b. Access to equipment.
c. Access to SMEs.
d. Process used to prepare art.

Discussion

Mr. Hart described task analysis as an initial listing of tasks with as many steps as possible listed in their proper sequence. Discussion then turned to the difference between task analysis and procedure writing by a technical writer. The consensus was that there isn't as much difference, given today's practices, as there used to be in the past. Discussion then centered on the topic, "Is task analysis worth the cost and to what level of detail do you do it?" Group agreement was that it was necessary and that the level of detail depends upon your target population.

Discussion of the number and type of subjects needed vs. the cost involved (for validation) exacted various opinions. Mr. Hart said that the bottom line was, "What assurance of quality does the customer want?" Contractors had mixed experiences with validations; the favorable experiences came from those who said that the validation was planned from the program onset and contractor personnel conducted the validation. Don Finegan commented that the Army puts a target audience description in their RFP.

Discussion of the readability formulas used to specify reading level of a target audience brought out points about their nonvalidation and nonmeaningfulness to users.

The group agreed that some measure of communicability was needed and that readability formulas were not the best.

The advantages and disadvantages of block diagrams vs. schematic diagrams were discussed. The general consensus was that, regardless of whether block diagrams, schematics, or MDCs are utilized, these items are high-cost items requiring skilled writers to produce them and skilled technicians to utilize them.

REDUCING JPA DEVELOPMENT COSTS

Dr. Kay Inaba
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Canoga Park, California

Presentation

Let me first explain my perspective on this problem. I'm approaching this from the viewpoint of a practitioner as opposed to a researcher. There are four areas that we have found we have to pay quite a bit of attention to, with some areas needing more attention than others. The first area is adjusting the format. Over the years, we found that we really haven't had to adjust the format all that much. In most cases, the adjustments are primarily to gain the acceptance of experienced technicians. We find that we never have any problem with inexperienced technicians, always the experienced ones. We find that these changes will most often have to be made at a cosmetic level as opposed to a content level.

The second area is overcoming barriers of acceptance. One way to overcome the "barrier" of the experienced technician is to adjust the format. Another way is to provide what we call "system explanations," or theory of operation of the equipment. We have found that many experienced technicians tend to get insulted by JPAs and feel as though you're asking them to do a "monkey see, monkey do type" operation. Therefore, we've developed a parallel set of documents (i.e., to "system explanations"). These documents tend to lend credence to the fact that management is interested in whether the technician knows how the system works. Another set of "barriers to acceptance" is the system acquisition manager. Once in a while, we run into an enlightened acquisition manager; however, they are the exception rather than the rule.

The third area is the measurement of performance for JPAs. As long as people aren't held accountable for proper performance of maintenance, it doesn't matter whether JPAs are used or not. From the technician's point of view, having JPAs means they have to do something different; so they resist this change. Things change somewhat when performance is measured. Whether or not the technicians are held accountable for their performance, their performance becomes visible and, therefore, more receptive to accepting help.

The fourth area is cost. In my experience, cost is probably the biggest single barrier for JPA application. Inevitably, when JPAs are considered, cost is the first question--especially if a technical manual already exists. My experience has been primarily with industry. I had a recent experience with a major defense contractor in the aerospace industry. They already had technical documentation and, although they agreed with the value JPAs conceptually, they essentially said "forget it" when we got to the topic of cost.

In terms of cost, I'd like to separate what I call the "front-end-analysis" from the JPA generation. I will address both topics, but, by separating them, I think I can better define how we have been able to stabilize costs in each area. Given that distinction between the two cost phases, we feel we've been able to stabilize production costs primarily through the use of computer-aided authoring systems that we call computer-aided technical information preparation system (CATIPS). Though this program is far from perfect, it has enabled us to semiautomate the production process. This program is really an evolution of

the manual process that we developed for presentation of information for maintenance organization (PIMO), and we eventually fine tuned it.

We wanted to recognize that the process of preparing JPA is something different from the process ordinarily used to prepare technical manuals. We recognized that you couldn't give a bunch of technical writers a new specification and tell them to "go to it" and expect them to meet the specifications. There's nothing in the specifications (that were developed 10, 15 years ago) that said that you had to write obscure information. If they (the writers) could have done it properly, they would have. There isn't much that we do in JPAs that is prevented by the specifications. It is practice that has resulted in poor manual preparation. Given that it is practice, getting a new set of specifications to writers isn't going to result in better manuals. So, what we did was to break down the process of writing--that is, converting technical engineering type data into JPAs--into steps and regroup these steps. In the computer-aided format that exists now, the program took us about 2 years to develop.

With that program, I break down cost into three major areas: The first is what I call "technical management," which is such things as interacting with subject matter experts, utilizing technical engineering data, and basically transforming the technical information through the writing process. The second is technical personnel; and the third, production. Quite often I've been asked, "What would happen if we took away the graphics or illustration portion of the JPAs?" My opinion is that, if we did so, only a 20 percent reduction in cost would be achieved. In other words, in my opinion, there's no reason not to use text graphics, if you can reduce the cost by effective management of the technical data rather than by eliminating the graphics per se.

Production areas that we've identified for major improvement are graphics editing and interactive generation of text. When I say "aid" in the construction of text, I mean exactly that. I don't mean text processing per se. Some of the recent studies in text processing have shown that about 60 percent of a person's time is spent just trying to get information from his head into the form of sentences and paragraphs. In using text processors, the text processor usually helps in "massaging" the text after it has been created. In CATIPS, however, we put most of our effort into helping the writer create the text in the first place. The reason is very practical. The high cost of creating text means we have to charge the customer more or swallow the cost ourselves, thereby decreasing the probability of getting the contract.

Given such a method of handling the text, we found that the major cost drivers are: (1) troubleshooting and (2) quality of the input data. An area that I feel has a major impact on cost is the decision on how to go about aiding troubleshooting or handling troubleshooting tasks. If you decide to proceduralize troubleshooting, you can expect to increase the number of pages by 65 to 130 percent. We find that, if you do it properly, the cost per page isn't that much greater, although it is greater than a conventional manual. The big factor is the volume, however. Some alternatives may be to provide logic trees or similar text-graphic materials to highly skilled technicians. Another alternative is simply to use schematics. The use of particular techniques, of course, depends on the associated training program. Some espouse intensive training and using only good block diagrams. I feel that this area could have a significant impact on the cost of JPAs. Thus, we need to focus on how to handle troubleshooting.

The second area is the quality of the input data, and this leads us to some relevant myths. First, I don't believe in task analysis as it is implemented in the greatest percentage of cases. It seems that the primary orientation is to crank out a whole lot of

data that are seldom if ever used. I believe that if you're going to do an analysis you should "pinpoint" the efforts to produce outputs that are definitely going to be used.

The development of a task identification matrix is essential, but if you look at the capability that is required to develop a task identification matrix from scratch (i.e., using only engineering data), you'll find that the kind of analyses required is not normally considered to be human factors. The need is really for engineering analyses. Let's consider, for example, one that determines whether a particular piece of equipment needs to be inspected or checked at a given frequency. Now, that's the type of analyses required to develop a task identification matrix and that I would consider to be an engineering analysis.

Another myth that I've heard is, "JPAs have to be perfect." To some extent, that's true. However, if you try to make each JPA perfect, the cost is going to go "sky high." We find it is important to orient properly the users (i.e., to deal realistically with minor deficiencies in the JPA). Essentially any JPA could be made more perfect but, in most cases, the JPAs are useful and usable as is. Attempting to achieve a "perfect" JPA is going to drive the cost up tremendously.

Other problems related to task analysis include conducting essentially the same analysis over and over again. There are considerable similarities between systems. For example, most electronic systems have quite similar skill demands. I'm not saying that one shouldn't conduct a thorough task analysis, but that one should only analyze areas for which the skills are new, as opposed to repeating the same analysis and hiding the useful information with a multitude of pages.

In taking a look at some of the analyses, I can't overemphasize the importance of engineering analyses, as currently known in the form of LSAs. I firmly believe that we should provide human factors support for the people who are involved in the development of the LSARs. Just because the quality of the data (LSARs) is not good at this time, we should not continue to reject these data as the human factors community has done for so many years. By rejecting the LSA efforts, we've taken full responsibility for generating the data. In fact, the human factors community does not have the capability to generate this type of data from scratch. We usually get the data by querying the subject matter experts. We even have the audacity of calling the effort a form of analysis, when in fact it is not. Sometimes we're lucky and get good subject matter experts and get good results. However, more often than not, we are not lucky. I contend that it is much more realistic to make the LSA people accountable for the data and help them improve their process.

We have learned to separate the price for "front-end" analysis and JPA generation. We tell the customer that the front-end data that they provide will directly determine the quality of the final product. If it is poor, then the final product will be very usable, but still poor. We let them know that, if they want help in cleaning up these data, then we will provide such help. We let them know that it will cost them exactly the same for the production whether or not they choose to clean up the input data, but the responsibility for quality rests with them.

We do not always succeed in getting the customer to accept the responsibility for the technical content. Life becomes much more difficult in such cases, but we no longer try to correct the problems ourselves. At the minimum, we share the responsibility--especially since we try to make our position clear from the outset.

We also give the customer the option of changing the format of the JPA because the material is stored electronically and the changes can be made easily. It does cost a certain amount of extra money to make these changes; however, the electronic storage of the data reduces these costs. Keep in mind that it is a buyer-driven market and we feel that we must meet the needs of the customer.

Regarding troubleshooting materials, my experience has been that 90 percent of the people who conduct the failure mode effect analyses (FMEAs) and dependency analyses don't know how to do them correctly. This directly affects the quality of input data for troubeshooting tasks. One possibility for improving these data is to let the producer know that we are going to cross-check the analysis (not a full-blown analysis, but a limited check). A better approach is to agree upon a process and teach this process to the LSA specialist. However, this is an expense that many organizations are not willing to incur.

Discussion

Initial discussion of barriers to JPA implementation highlighted a potential role for the government in helping contractors "get a handle" on their cost estimates, while reducing the "fear" of JPA production in relation to other technical information presentation methods.

Dr. Inaba briefly discussed the use of block diagrams and certain techniques that may be used for "cosmetic purposes." Dr. Inaba was asked how cost affects competition for project awards. He explained the difference in costing between "strictly JPA development" projects and those where the technical information JPA was purchased noncompetitively. He was asked whether he would purchase a JPA package that was 10 times costlier and 20 percent more effective than another package. Dr. Inaba explained that the procurement/development system was not set up to reward the person delivering the more cost/effective system; therefore, cost vs. effectiveness would not even be considered in the procurement stage. This is why they (Xyzyx) break down cost into two stages--(1) front-end development, and (2) production--and instill the quality responsibility on the customer.

Discussion then turned to identifying the point of responsibility for conducting upfront data analysis of troubleshooting tasks. The need for FMEA or dependency analysis was expressed by Dr. Inaba with the concern that the customer does not usually bear the responsibility for these analyses. Discussion then focused on the responsibility for these analyses within an organization. The design engineer, as opposed to the technical writer, was targeted for doing these analyses, although the actual practice of this doctrine differed and the burden of these analyses on the engineerng people was considered to be substantial. The discussion of background data collection and organization identified the technical publications people as the heaviest users of LSA data and noted that, while the merit of the LSA concept could be established, there were serious problems with the implementation of the process.

SUMMARY OF COST FACTORS FOR ONE JPA DEVELOPMENT TASK

Mr. William Conroy
Raytheon Service Company
Ventura, California

Presentation

What I have done for my presentation is to put together a summary of a single task that we performed up in Ventura. I will show how we went about estimating cost and what happened as the task evolved. The task was a simple one involving the development and production of maintenance requirement cards (MRCs). The tasks were defined and the maintenance requirement description was already written for 22 tasks that were involved.

One of the things I had to take into consideration was that my personnel who were available to work on this job were not familiar with the equipment. By "not familiar," I mean they didn't understand the nuts and bolts of it, although they very quickly learned what it was supposed to do and what type of equipment it was. Another factor was that the equipment was available locally and it was on the station at the Naval Ship Weapon Systems Engineering Station (NSWSES), 10 miles from our facility. The equipment was available to us any time we wanted to go and take a look at it and that also meant that we could validate it locally. Specifically, this equipment was a new plasma display microprocessor terminal on the NATO Seasparrow Surface Missile System.

The tasks that were defined were all remove-and-replace procedures. The 22 procedures were defined in another technical manual written by another Raytheon organization. Considering our discussion today, I have to admit that I didn't even ask if there was an LSA available. What I would like to do (after this meeting) is find the LSA data and compare the two.

Since I knew the equipment and the people that were involved, this is the kind of weighting that I put on the types of people who would be producing the MRCs (see Slide 1). I can't say that this is a normal rating because every job will be different. In this particular case, I knew the capabilities of the writers who were going to be involved in the job and was able to use that information. Then, of course, I assumed that we would edit, type, and illustrate.

To get this number of pages, it's obvious that we assumed two pages of text to one page of illustration. In rating it, I was really hedging because I knew I would make a savings as some of the art work would be redundant. On the other hand, not knowing the guts of the equipment, there's always a possibility that illustrations that we did not think of would be required. Because of the time frame of this task, the engineering drawings were not available and we were working from an existing preliminary technical manual, certainly not written to any specification at this point. The illustrating factor is large because we had to illustrate and draw them by looking at the actual equipment, and this is more time consuming. In this case, we probably got a better product because the engineering drawings did not exist and we looked at the actual equipment.

ESTIMATING

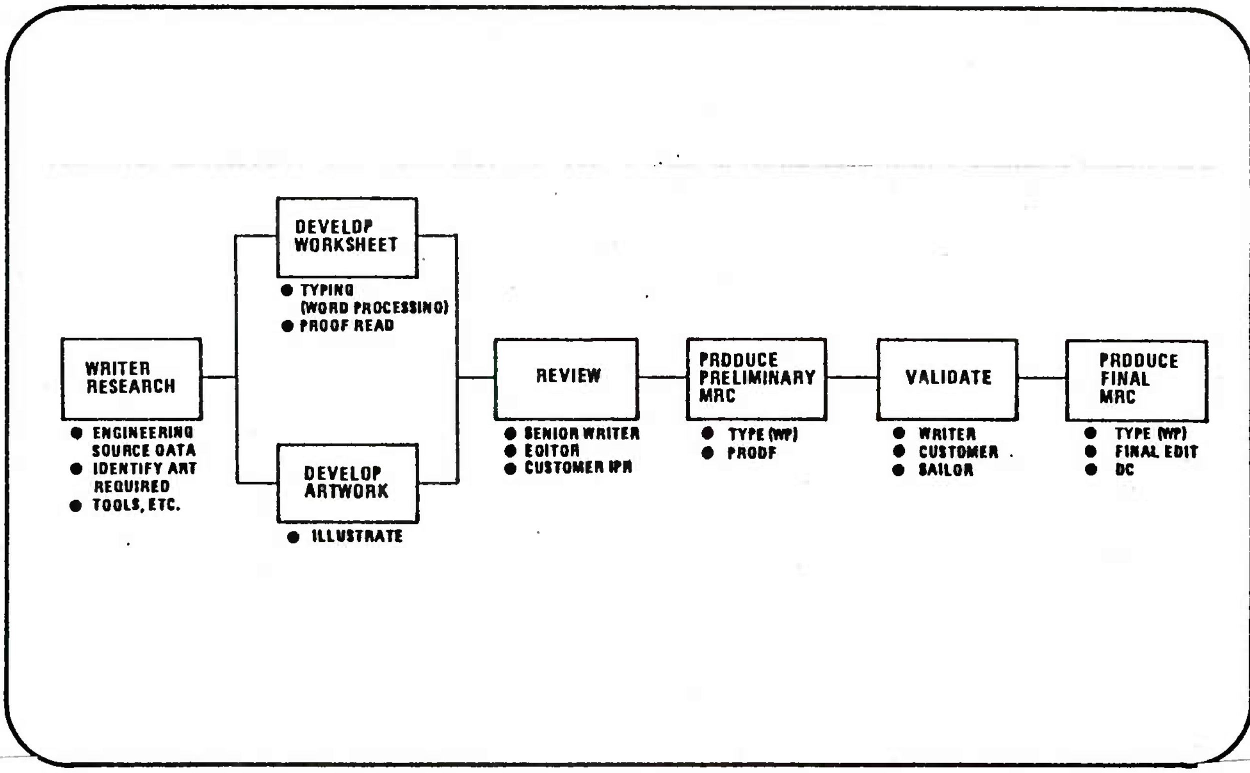
- MAINTENANCE REQUIREMENT DESCRIPTION – PROVIDED
- EXISTING PERSONNEL NOT FAMILIAR WITH EQUIPMENT
- EQUIPMENT AVAILABLE LOCALLY
- VALIDATION TO BE PERFORMED LOCALLY

ESTIMATE

• WRITING	44 TEXT PAGES	X	8.5 HRS =	374
• EDITING	44 " "	X	.3 HRS =	13
• TYPIST	44 " "	X	.7 HRS =	31
• ILLUSTRATING	22 " "	X	8.5 HRS =	187
				605

Conroy: Slide 1

Slide 2 shows the general sequence of the work that we do and the order in which we usually do it. We do some research and try to locate any engineering data, if we can. Then, we would identify what art we would generate, and the tools required for the job. In other words, these are things that should have been on an LSA. At this point, the writer puts together rough text that is typed and then proofread while we develop the artwork. Writers and illustrators were able to go to the equipment and work on the procedures by looking at the equipment. At this point, we develop a worksheet; however, it is not the formal MRC worksheet. We view it for general accuracy; for example, if we take something apart, we check if it is put back together again and general "editing-type" things. We try to consider the sailor as much as possible. Most of the people that work for me in Ventura are ex-sailors and they understand the working environment and the sailor. They understand the language that has to be provided here. For this review, we put the information in the regular MRC format using word processing throughout. After this initial production, we did a validation utilizing a writer, "customer-provided" person, and a sailor. They allowed us to remove quite a few of the modules, and we actually did such and put them back in.



Conroy: Slide 2

[Note. At this point, a discussion occurred concerning the particular background for this study and Slides 3 and 4 were presented. Results of the study showed that inaccurate task definition data changed the complexity of the MRCs, requiring decreased preparation time with increased time for correction of task data. The complexity and amount of required research was highlighted in Slide 5 as the primary cost driver. Level of detail and the requirements for artwork were presented in Slide 5. Mr. Conroy commented that safety was a particular consideration, given that these people are working in an unfamiliar environment. The presentation text continues with the "Safety" item on Slide 5.]

The working environment must be considered. Quite often in the past, when we were far removed from the actual equipment, we missed many of these considerations. For example, equipment location is a critical environmental factor when one piece of equipment is four decks and two doors away from another piece of equipment, and the guy is constantly running back and forth to look at a particular signal. In other words, the writers who are working on the particular JPA should have this knowledge of the overall environment and what it takes to get the job done. Consideration of the supply system is necessary when writing troubleshooting tasks. Often, you write, "if this card is bad replace it, and if this other card is bad, replace that one." Well the first card might involve a certain amount of delivery time, and the second card might take even longer. I think we have to remember this in developing troubleshooting aids. In other words, the cards aren't right there for them to just take, insert, and replace. In some systems, a ready-spares cabinet is available with parts, but in many of the newer systems I have not seen this to be true.

ACTUAL

TASK WAS REDEFINED; OF THE 22 ORIGINAL PROCEDURES IT WAS DECIDED THAT 5 WERE NOT REQUIRED BUT 4 OTHERS WERE – AND THESE OTHERS WERE MORE COMPLEX THAN ORIGINALS –

ACTUAL

WRITING	33	TEXT PAGES	X 8.5 HRS	=	281
EDITING	33	" "	X .3 HRS	=	10
TYPIST	33	" "	X .7 HRS	=	23
ILLUSTRATING (UNIQUE)	14	" "	X 8.5 HRS	=	119
					433

ACTUAL HOURS USED = 509 HRS

Conroy: Slide 3

COST DEPENDS ON COMPLEXITY AND AMOUNT OF RESEARCH REQUIRED

ESTIMATES FOR AN AVERAGE PAGE OF TEXT ARE:

RESEARCH: / WRITE DRAFT:	8 HOURS
TYPE WORKSHEET:	0.15 HOURS
PROOFREAD/EDIT:	0.1 HOURS
TYPE PRELIM MRC PAGE:	0.15 HOURS
PROOFREAD:	0.1 HOURS
TYPE CORRECTIONS:	0.1 HOURS
VALIDATE:	0.5 HOURS
TYPE CORRECTIONS:	0.1 HOURS
PROOF:	0.1 HOURS
TYPE CORRECTIONS:	0.1 HOURS
Q.C.:	0.1 HOURS

AVERAGE PAGE: SR. WRITER — 8.5 HOURS
PROOF/EDIT — 0.3 HOURS
TYPING — 0.7 HOURS

AVERAGE FULL PAGE ILLUSTRATION:
(TRACE ENG. DRAWING/ REDUCE) — 8 HOURS
REPRODUCE/PASTE UP — 0.5 HOURS

Conroy: Slide 4

CONSIDERATIONS

LEVEL OF DETAIL

- REQUIRES MORE CONSIDERATION OF ENVIRONMENT
- SHIP CLASS DIFFERENCES

ARTWORK

- SHOULD CLEARLY IDENTIFY PHYSICAL CONTEXT
- MUST SHOW VIEWS THAT ARE POSSIBLE

SAFETY

- MUST BE AN EVEN STRONGER CONSIDERATION THAN WITH NON-EPICS SAILORS

WORKING ENVIRONMENT

- DISTANCES BETWEEN WORK STATIONS
- SUPPLY SYSTEM

Conroy: Slide 5

Discussion

Mr. Conroy defined the 22 MRCs as having more text than illustrations, but were expected to be on-the-job aids (i.e., JPAs).

Peculiarities of the development background behind Mr. Conroy's example were noted; namely, that technical drawings and technical manuals were not purchased with the original system. Although one conference participant could not understand why, another commented on the cost savings by not having to update, catalogue, purchase such information initially. Group discussion of the advantages/disadvantages of "automatic" technical manual purchasing continued, with the predominant feeling that decisions should be made on a case-by-case basis.

Discussion then centered on Mr. Conroy's "working environment" considerations in Slide 5. The availability of spare cards for use in troubleshooting tasks was discussed, as well as the utilization of spare parts for troubleshooting. Mr. Conroy summarized that there must be more thought involved in developing troubleshooting procedures, given that spare parts are not instantly available. He emphasized the point that the user's environment must be carefully considered by writers.

COMPUTER-BASED TECHNICAL ORDER ASSESSMENT METHOD (PAGES)

Ms. Rosemarie J. Preidis
U.S. Air Force Human Resources Laboratory
Wright-Patterson Air Force Base, Ohio

Presentation

Currently we have a computer-based technical order assessment method called PAGES. It is operated in an interactive mode. These algorithms are used to estimate the content of troubleshooting and nontroubleshooting data for both flightline and shop maintenance. PAGES is meant for application during the conceptual and validation phase to provide relative content and quantity estimates. PAGES may be used to estimate either conventional or task-oriented manuals. PAGES estimates pages for both electrical and mechanical/hydraulic systems.

These algorithms are dependent on a knowledge of the system, the number of subsystems, and the quantity of line replaceable units and shop replaceable units within the target system. The user can directly input this data at the terminal or he may use the equipment configuration data bank of the reliability and maintainability model.[6]

The PAGES model provides page estimates for 12 different page types. These page types are:

1. Narrative.
2. Half-tone art.
3. Half-tone explosion.
4. Electronic line art.
5. Exploded line art.
6. Fault isolation chart.
7. Fault isolation schematic block.
8. Access line art.
9. Fault isolation schematic flow.
10. Fault isolation schematic mechanical/hydraulic.
11. Job guide narrative.
12. Job guide illustration.

PAGES algorithms can best be described by example. The following example involves the algorithm to predict the content of a fault isolation manual to support the task-oriented approach to flightline troubleshooting. The total pages are calculated as follows:

No. pages = 2 fault isolation charts/subsystem
+ 2 fault isolation charts/LRU
+ 1/2 page narrative/LRU
+ 2 access line art pages/LRU
+ 2 fault isolation schematic block pages/subsystem
+ 1 fault isolation schematic flow page/LRU.

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[6]The reliability and maintainability (R&M) model is an average value model that provides outputs of R&M parameters in a form useful for initial studies and tradeoff analyses in early acquisition.

The cost estimation portion is presently a manual operation. It is based on a page type/cost area matrix (Slide 1). Cost data are presented in labor hours and unloaded costs. This matrix is used to present the time and cost estimates for the various type pages considered.

The technical order content and cost estimation methodology is based on a F-16 technical order study that took place during May-September 1978. At the request of the F-16 system program office (SPO), the Air Force Human Resources Laboratory (AFHRL) performed a content and cost analysis of the technical order requirements for the F-16 production aircraft. The purpose was to provide "baseline" information to F-16 SPO procurement personnel for use in contract negotiations concerning the purchase of production aircraft technical orders. AFHRL developed algorithms for predicting content of technical orders for task oriented organizational data and the conventional intermediate and depot data. The algorithms were based on the page count and page type of F-15, F-16 (FSD) technical orders. The approach used in collecting cost data was to obtain cost estimates from several contractors for developing the different types of pages. The basic guidelines to the contractors were that engineering drawings were available and that a front-end task analysis was complete. The composition with type page costs. The information provided by the algorithms and cost data was instrumental in significantly reducing the negotiated purchase price of the F-16 production aircraft technical orders.

Addendum

Ms. Preidis picked a hypothetical electrical system and inserted these data into her PAGE algorithm. Her hypothetical system contained 32 subsystems and 77 LRUs, which yielded a total of 552 pages. She then explained the generation of the cost estimation matrix, which was done by contacting three contractors and asking them how many labor hours would be involved given a certain number of page and illustration requirements.

Ms. Preidis explained that these algorithms are part of a larger overall project called Project 1959. The project encompasses training requirements, technical data, reliability, and maintainability in terms of looking at one design vs. another design. This particular page-estimation package is concerned with comparisons of the technical data requirements of various designs. She also explained that these algorithms have not been validated yet and their purpose at present is to develop a base-line estimate of the number of pages and amount of cost involved.

Discussion

Ms. Preidis indicated that electrical systems, as specified in paragraph 1 of her paper, include electronic systems. Subsystems were defined as being based upon a work breakdown type of coding system.

As a result of the technical-order study conducted in 1978, a reduction in cost for the F-16 proposal was realized. Discussion revealed that a major source of that reduction was in reduced hours estimated for certain work areas. Discussion of the models' weaknesses included the fact that a writer may prepare a block diagram as an initial aid to guide his writing; however, this time is not considered as illustration time even though he has drawn the diagram. The conclusion was that, for the model's purposes, this was a minor drawback and the work breakdown categories could never be "black and white."

Page Type / Cost Area	Writer @9.50	Editor @7.40	Illustrator @6.60	Typist @4.90	Proof Reader @4.60	Parts Catalog @6.60	Production @6.10	Q/A @6.10	Supervisory @11.80	Total Material	Total Hours DL & Mat $
Job Guide Text Note 1	5.0 47.50	1.0 7.40	0.1 .66	0.7 3.43	0.26 1.16	See Note 2	0.5 3.06	0.1 .61	0.4 4.72	3.00	8.05 71.52
Job Guide Illustration (no repeats)			8.0 52.80	See Note 3					0.7 8.26	5.00	16.3 124.62
Job Guide Illustration (repeats)			3.0 19.80						0.6 5.90	7.00	10.1 91.26
Fault Description Chart	12.0 114.00	1.0 7.40	4.0 26.40	1.5 6.75			0.7 4.27	0.6 3.05	1.0 11.80	3.00	20.7 176.67
FR/FI 1 Access Line Art	7.0 66.50		16.0 105.60	See Note 8					1.2 19.16	43.00	26.4 248.98
Fault Isolation (FI) Chart	12.0 114.00		4.0 26.40	1.5 6.75	See Note 10				1.0 11.80	3.00	20.7 176.67
FI System Schematic/ Block Diagram	9.6 90.26		16.0 106.60	See Note 9					1.4 16.52	8.50	29.1 235.59
FI System Schematic/ Flow Diagram			24.0 158.40						1.8 21.24	8.50	37.5 293.11
FI System Schematic Mech. Diagram			32.0 211.20						2.5 29.6	8.50	46.2 354.17
FI System Schematic/ Hydraulic										8.50	46.2 354.17
FR/FI 2 Access Line Art	7.0 66.50			See Note 8						3.00	51.7 324.92
Intermediate/ Depot Text	9.5 90.26	1.0 7.40	0.16 .99	1.6 7.35	0.5 2.30	See Note 4	1.26 7.63	0.5 3.05	0.7 8.26	3.00	16.1 130.23
Intermediate/ Depot Tabular (I/D)	9.6 90.25		0.6 3.30	3.0 14.70	0.6 2.30	See Note 4	1.26 7.63		0.8 9.44	3.00	17.06 141.07
I/D Half Tone Art	3.0 28.50		6.0 39.60				0.7 4.27		0.5 5.90	15.00	10.7 103.72
I/D Half Tone Explosion	7.0 66.50		10.0 66.00				0.7 4.27		0.9 10.62	16.00	19.1 172.84

COST–DIRECT LABOR DATA – SOURCE I

Preidis: Slide 1

Page Type / Cost Area	Writer @9.50	Editor @7.40	Illustrator @6.60	Typist @4.90	Proof Reader @4.60	Parts Catalog @6.60	Production @6.10	Q/A @6.10	Supervisory @11.80	Total Material	Total Hours DL & Mat $
IPB Half Tone Art		1.0 7.40	8.0 52.80			9.0 59.40	0.7 4.27	0.5 3.05	0.9 10.62	15.00	19.1 152.54
I/D/IPB Sectional Link Art	2.0 19.00	↓	18.0 118.80		1.0 4.60	2.0 13.20	↓	↓	1.25 14.75	3.00	26.45 188.07
I/D/IPB Cutaway Line Art	↓	↓	10.0 66.00		↓	2.0 13.20	↓	↓	0.85 10.03	3.00	18.05 130.55
I/D/IPB Explosion Line Art	4.0 38.00	↓	24.0 158.40		↓	4.0 26.40	1.25 7.63	↓	1.8 21.24	3.00	37.55 269.72
Schematic/ Electronic Line Art	2.0 19.00	↓	12.0 79.20				0.7 4.27	↓	0.8 9.44	3.00	17.0 125.36
Block Dia./ Electronic Line Art	↓	↓	8.0 52.80				↓	↓	0.6 7.08	3.00	12.8 96.60
Test Setup Electronic Line Art	↓	↓	8.0 52.80				↓	↓	0.6 7.08	3.00	12.8 96.60
Wiring Dia. Electronic	2.0 19.00	1.0 7.40	8.0 52.80				0.7 4.27	0.5 3.05	0.6 7.08	3.00	12.8 96.60
1–Fold Line Art	↓	↓	8.0 52.80	◄ See	Notes	5 & 6 ►	↓	↓	0.6 7.08	5.00	12.8 96.60
2-Fold Line Art	↓	↓	16.0 105.60	↓	↓	↓	↓	↓	1.0 11.80	8.50	21.2 169.62
3–Fold Line Art	↓	↓	24.0 158.40	↓	↓	↓	↓	↓	1.4 16.52	13.50	29.6 222.14
4–Fold Line Art	↓	↓	32.0 211.20	↓	↓	↓	↓	↓	1.8 21.24	16.75	38.0 282.91
6–Fold Line Art	↓	↓	40.0 264.00	↓	↓	↓	↓	↓	2.2 25.96	21.00	46.4 344.69
IPB Tabular	See Note 7			2.0 9.00		14.0 92.40	↓	↓	0.85 10.03	3.00	18.05 121.75

COST–DIRECT LABOR DATA – SOURCE I (continued)

Preidis: Slide 1 (Continued)

Discussion of tailoring the algorithms to specific user types (i.e., the same type of job guide might be different for different groups) brought out points that a job guide (as used in the algorithm) already indicates a user type, and very specific user differences would only have a small influence on page numbers. A discussion of troubleshooting procedures brought out an earlier point that troubleshooting vs. nontroubleshooting procedures significantly changed page volume, but once a decision was made selecting troubleshooting as a method of choice, the variation was small.

A general comment that these algorithms could be better applied to a higher level system, such as an F-16 aircraft, than to a smaller radar system was mutually agreeable. A question concerning the number of equipment design changes and the effect of the number of changes on the JPA text revealed that data of this type were available in AFHRL data files and that these changes definitely influenced cost. The number of changes are an uncertainty factor usually included in costing and also included in the hour estimates for the AFHRL estimates. The number of changes are usually estimated by using historical data to compare past and present systems. A point was made that the customer must know if this uncertainty factor for equipment changes was included in a cost estimate because it could account for a wide discrepancy between two contractor bids on the same procurement.

JPA PRICE ESTIMATING: IMPACT OF JPA'S NATURE AND CIRCUMSTANCES EXPECTED FOR ITS DEVELOPMENT

Mr. Fran Rahl, Jr.
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Presentation

JPA price estimating as currently accomplished is a combination of art and science that I approach from several directions, depending on circumstances. On an existing system already documented in a traditional format, a fairly accurate task count can be made. Estimating norms based on historical performance or time-and-motion study are then applied to determine page count and cost by labor type. On developmental systems or other undocumented systems, task analysts first estimate the number of tasks and then employ page norms to determine the cost. Where insufficient time or equipment definition exists, a rough order-of-magnitude estimate can be made by assuming the JPA price will be a certain proportion of the total program price (where such knowledge exists). Finally, a "management calibration" number will always be developed using rules of thumb, comparisons with similar previous jobs, or general feeling for the expected level of effort.

Regardless of the method(s) employed, innumerable variables of two general categories (Slide 1) affect the estimator's viewpont and ultimately the JPA price estimate: The nature of the JPA and the expected circumstances under which it will be developed.

JPA PRICE IS A FUNCTION OF:

- THE NATURE OF THE JPA ITSELF
- THE CIRCUMSTANCES SURROUNDING ITS DEVELOPMENT

Rahl: Slide 1.

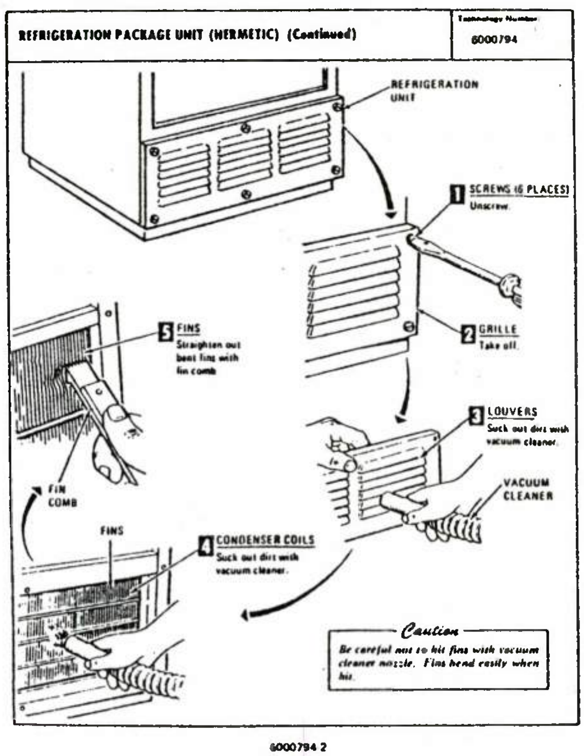
The nature of the JPA (Slide 2) can readily be determined by looking at it for physical appearance characteristics such as text/graphics mix, size, color, gross volume, density, etc. Of course, the detailed specification requirements are a function of user profile, task types and quantities, equipment type, and specification items reflecting current thinking on usability. Slides 3 through 10 are examples of some of the forms Westinghouse has employed in the past few years. These samples, arranged from lowest intended user-skill level to highest, illustrate the effects of desired appearance on cost, when compared on Slide 11. Unskilled samples A-D (Slides 3-6) have the highest proportion of illustration labor as compared to analytic and writing labor. In some instances, this labor mix results in a lower price per page; however, the need for more pages may offset the savings. Semi-skilled sample E (Slide 7) has a higher mix of writing to illustrating than unskilled; however, fewer pages are required. Skilled sample F (Slide 8) has a high writing content and has the greatest information density of the technical data forms normally thought of as JPAs. Skilled samples G-H (Slides 9, 10) are conventional, have the highest concentration of writing labor, and have the fewest pages per task.

THE NATURE OF THE JPA IS DEFINED IN ITS PHYSICAL APPEARANCE, AND IS A FUNCTION OF:

- USER PROFILE
- TASK TYPE, QUANTITIES
- EQUIPMENT TYPE
- SPEC REQUIREMENTS

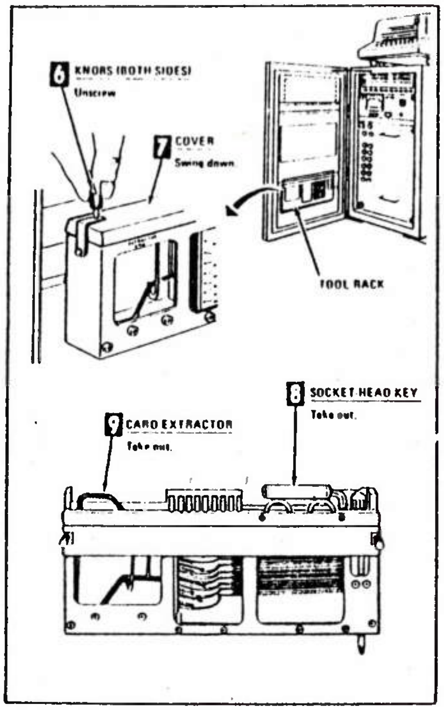
} TEXT/GRAPHICS MIX, DATA DENSITY, GROSS VOLUME, ETC.

Rahl: Slide 2

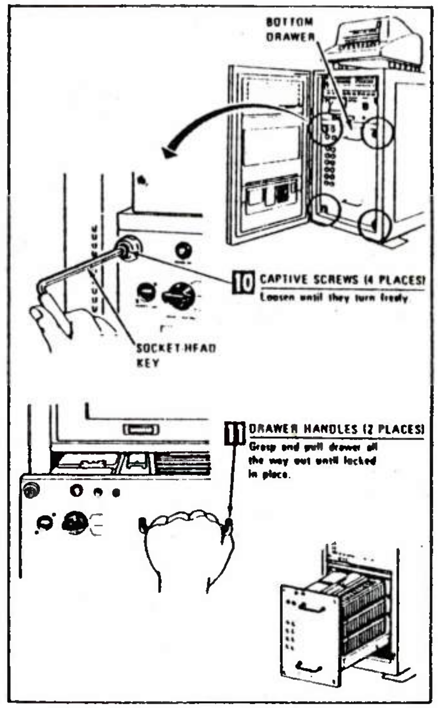


EXAMPLE A - UNSKILLED; DIRECT VISUAL ACTION CUES WITH MINIMUM TEXT - (STANDARD SIZE)

Rahl: Slide 3



4 of 16



5 of 16

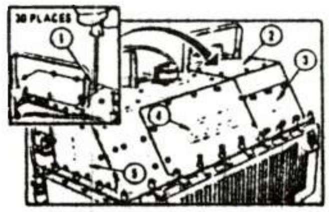
EXAMPLE B - UNSKILLED DIRECT VISUAL ACTION CUES WITH MINIMUM TEXT - (POCKET-SIZE)

Rahl: Slide 4

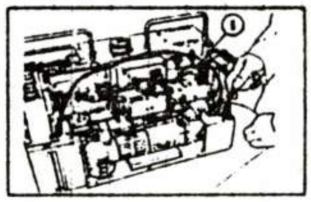
-SAMPLE-

REMOVING PRESSURE VESSEL

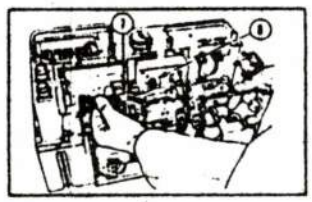
1 Loosen 30 captive screws (1) on covers (2, 3, 4, 5) with no. 3 cross tip screwdriver Remove covers.



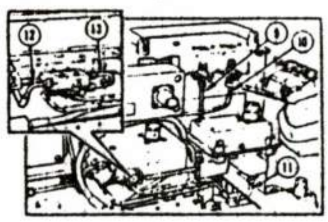
2 Disconnect coax cable (6) at both ends with 11/16-inch and 7/16 inch open end wrenches.



3 Disconnect wire harness (7) and electrical plug (8).



4 Disconnect five tubes (9, 10, 11, 12, 13) with 3/16-inch open end wrench.

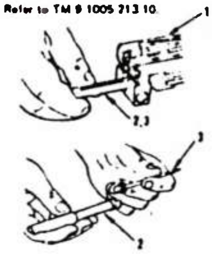
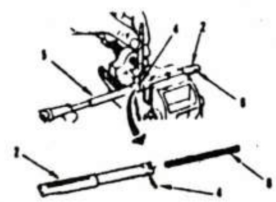
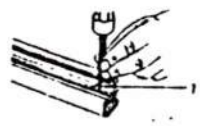
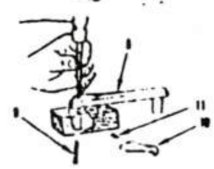


1 - 2

EXAMPLE C - UNSKILLED; FULLY PROCEDURALIZED TEXT WITH CUED TASK STEPS

Rahl: Slide 5

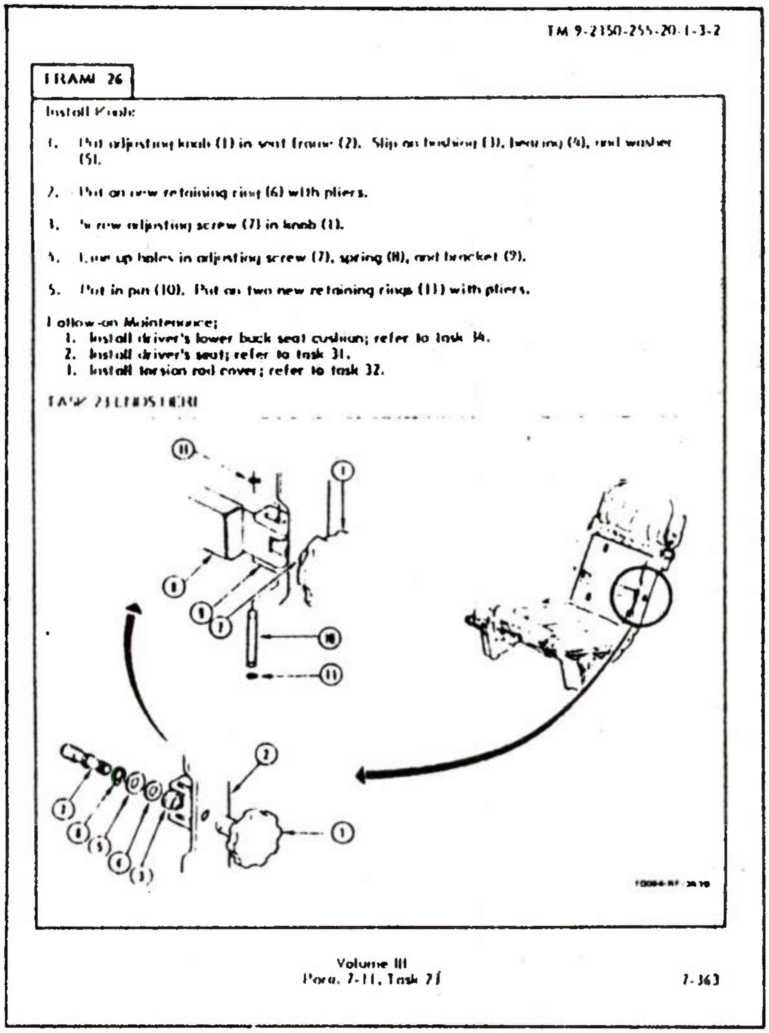
TM 9-1005-213-24&P

LOCATION/ITEM	ACTION	REMARKS
DISASSEMBLY		
1. Machinegun/Bolt	Field strip machinegun.	Refer to TM 9 1005 213 10.
2. Bolt/ Bolt (1) Extension (2) Firing Pin (3)	Tilt bolt (1) and pull out extension (2) and firing pin (3). Pull out firing pin (3) from extension (2).	
3 Bolt/ Pin (4) Tool (5) Spring (6)	Put extension (2) into vise with pin (4) facing up. Push tool (5) on end of extension (2) to compress spring (6). Tap out pin (4). Get rid of spring (6).	
4. Bolt/ Headless Pin (7)	Drive out and get rid of pin (7) from bolt (1).	
5 Bolt/ Extractor (8) Pin (9) Ejector (10) Spring (11)	Pull extractor (8) out of bolt (1) and place on block of wood as shown. Drive out pin (9). Pull out ejector (10) and spring (11).	

3-33

EXAMPLE D - UNSKILLED; FULLY-PROCEDURALIZED WITH SUPPORTIVE CUES (TABULAR)

Rahl: Slide 6



TM 9-2350-255-20-1-3-2

FRAME 26

Install Knob:

1. Put adjusting knob (1) in seat frame (2). Slip on bushing (3), bearing (4), and washer (5).

2. Put on new retaining ring (6) with pliers.

3. Screw adjusting screw (7) in knob (1).

4. Line up holes in adjusting screw (7), spring (8), and bracket (9).

5. Put in pin (10). Put on two new retaining rings (11) with pliers.

Follow-on Maintenance:
1. Install driver's lower back seat cushion; refer to task 34.
2. Install driver's seat; refer to task 31.
3. Install torsion rod cover; refer to task 32.

TASK 23 ENDS HERE

Volume III
Para. 7-11, Task 23

7-363

EXAMPLE E - SEMI-SKILLED; FULLY PROCEDURALIZED WITH SUPPORTIVE CUES (FRAME PAGE)

Rahl: Slide 7

T.O. 1C-141A-2-4JQ-4

REMOVE AND INSTALL FUEL PUMP

Remove And Stow Low Pressure Switch Assembly:

13 Disconnect clemp (3) with ettached load from tube (2)

14 Disconnect coupling nuts (1) at both ends of tube (2) Remove end cap tuhe

15 Remove two nuts (4) securing switch hrecket (6) to bottom of fuel pump (7)

16. Remove entire switch assemhly (5) with attached electrical lead

17 Stow switch assembly (5) clear of fuel pump. If necessary, tie or tape switch to engine structure.

18 Disconnect clamp (8) with attached tube (9) by removing locknut (10) from bottom of pump

2-12

T.O. 1C-141A-2-4JQ-4

2-13

EXAMPLE F - SKILLED; FULLY PROCEDURALIZED TEXT KEYED TO A SINGLE CUE/LOCATOR (FACING PAGE)

Rahl: Slide 8

T.O. 1E-3A-43-2-93-1

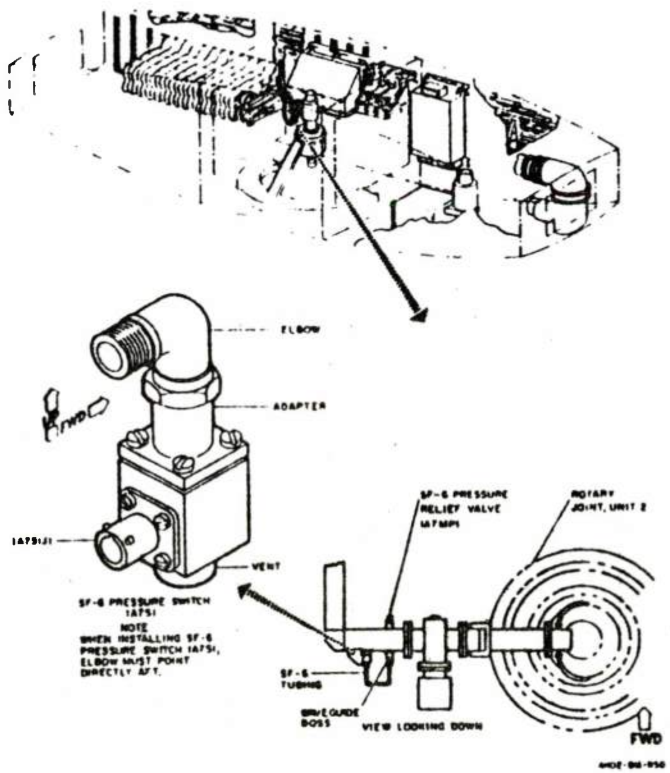


Figure 3-11. Antenna Waveguide Pressure Relief Valve 1A7MP1 and Pressure Switch 1A7S1 Removal/Installation

T.O. 1E-3A-43-2-93-1

3-45. INSTALLATION OF ANTENNA WAVEGUIDE SF-6 PRESSURE RELIEF VALVE 1A7MP1. (See figure 3-1.)

1. Ensure that all circuit breakers opened in paragraph 1-28 are still open and tagged.

2. Remove dust plug from waveguide opening. Apply silicone grease (MIL-L-4343) to O-ring on body of valve. Install valve and tighten until it bottoms.

3. Evacuate antenna SF-6 system and pressurize with SF-6 per paragraph 3-40.

4. Exit antenna pedestal per paragraph 1-29.

3-46. REMOVAL OF ANTENNA WAVEGUIDE SF-6 PRESSURE SWITCH 1A7S1. (See figure 3-11.)

1. Depressurize antenna SF-6 system and fill with air per paragraph 3-39.

2. Enter antenna pedestal per paragraph 1-28.

3. Disconnect cable connected to pressure switch connector 1A7S1J1. Cap all connectors.

4. Loosen coupling nuts securing each end of SF-6 tubing. Remove, bag, and stow SF-6 tubing assembly. Plug opening in waveguide.

5. Remove, bag, and stow two screws securing pressure switch to bracket. Remove pressure switch.

6. Remove, bag, and stow four screws securing elbow fitting and adapter to top of pressure switch. Bag and stow elbow and adapter assembly.

3-47. INSTALLATION OF ANTENNA WAVEGUIDE SF-6 PRESSURE SWITCH 1A7S1. (See figure 3-11.)

1. Ensure that all circuit breakers opened in paragraph 1-28 are still open and tagged.

2. Position elbow and adapter assembly on top of pressure switch and secure with four screws.

3. Secure pressure switch to bracket with two mounting screws and tighten securely.

4. Remove dust plug and install new aluminum seals on elbow fitting and waveguide boss. Install SF-6 tubing between elbow and boss. Torque coupling nuts to 105(±15) inch-pounds.

5. Remove dust caps and connect cable to pressure switch connector 1A7S1J1.

6. Exit antenna pedestal per paragraph 1-29.

7. Evacuate antenna SF-6 system and pressurize with SF-6 per paragraph 3-40.

3-48. REMOVAL OF SF-6 PRESSURIZATION CONTROL 3A19A1. (See figure 3-12.)

1. Close shutoff valves on SF-6 ground service cart if service cart is connected to aircraft.

2. Enter aft lower compartment per paragraph 1-34.

3. Ensure that shutoff valves on SF-6 gas tanks are closed.

EXAMPLE G - CONVENTIONAL

Rahl: Slide 9

Number:	Symptom/Title:	Revision No./Date
E-O	REACTOR TRIP OR SAFETY INJECTION (Cont.)	Basic 1 Sept. 1981

STEP	ACTION/EXPECTED RESPONSE	RESPONSE NOT OBTAINED
	NOTE • *Circled numbers show IMMEDIATE ACTION steps.* • *Foldout page should be open.*	
1	**Verify Reactor Trip:** • All rod bottom lights – LIT • All rod position indicators – ZERO • Neutron flux – DECREASING	a. Manually trip reactor. IF reactor will NOT trip, THEN go to ECA-1, ANTICIPATED TRANSIENT WITHOUT SCRAM.
2	**Verify Turbine Trip:** • All turbine stop valves – CLOSED	• Manually trip turbine.
3	**Verify AC Emergency Busses Energized:** • AC emergency bus voltage – NORMAL	IF NOT energized, THEN go to ECA-2, LOSS OF ALL AC POWER, STEP 3.
4	**Check If SI Is Actuated:** a. [Enter plant specific means]	IF NOT actuated, THEN go to ES-0.1, REACTOR TRIP RECOVERY.
5	**Verify Feedwater Isolation:** a. Flow control valves – CLOSED b. Flow control bypass valves – CLOSED c. Feedwater isolation valves – CLOSED d. Steam generator blowdown isolation valves – CLOSED	a. Manually close valves. b. Manually close valves. c. Manually close valves. d. Manually close valves.
6	**Verify Containment Isolation Phase A:** a. Isolation phase A valves – CLOSED (1)	a. Manually close valves.
7	**Verify AFW Pumps Running:** a. Motor-driven pump breaker indicator lights – LIT b. Turbine-driven pump steam supply valves – OPEN	a. Manually start pumps. b. Manually open valves.

(1) Enter plant specific list

2 of 11

Example H. Conventional-Tabular

Rahl: Slide 10

JPA TYPE SUMMARY AND COST FACTORS

USER PROFILE	RECOMMENDED FORMAT	% OF EFFORT			PAGE RATIO CONVENT. VS JPA
		TASK ANAL.	WRITING	GRAPHICS	
UNSKILLED (APPRENTICE LEVEL) 5TH - 7TH RGL	DIRECT CUE/RESPONSE-HIGHLY ILLUSTRATED (PRESENTED AS 'ACTION' CUES) - MINIMUM TEXT (RESPONSES) WRITTEN IN SHORT CONCISE MANNER AND KEYED WITH EACH TASK STEP. (SAMPLE A-D)	30%	10%	60%	1:10
SEMI-SKILLED (TECH SCHOOL GRAD AND/OR OJT) 7TH - 9TH RGL	SEPARATE TASK STEPS IN PROCEDURALIZED ORDER - GRAPHIC (CUES) DEPICTING LOCATION OF PARTS RATHER THAN 'ACTIONS' AS USED FOR UNSKILLED PERSONNEL (SAMPLE E)	30%	30%	40%	1:8
SKILLED (SPECIALIST-LEVEL) 9TH - 12TH RGL	FULLY PROCEDURALIZED TEXT KEYED TO A SINGLE GRAPHIC CUE EXPLODED OR LOCATOR VIEWS OF EQUIPMENT COMMONLY USED IN THIS TYPE OF FORMAT. (SAMPLE F)	30%	50%	20%	1:4
SKILLED (SPECIALIST-LEVEL) 9TH - 14TH RGL	CONVENTIONAL - EXTENSIVE NARRATIVE NON-PROCEDURALIZED - ILLUSTRATIONS USED FOR COMPLEX PROCEDURES ONLY GENERALLY, FORMATTED AS EXPLODED VIEWS (NON-CUED). (SAMPLE G-N)	-	90%	10%	1:1

Rahl: Slide 11

Conventional technical manuals serve as the standard for comparison in the page ratios (data density) shown in the chart. These kinds of data are also the least expensive for several reasons: (1) Negligible task analysis is required, (2) procedures can often be lifted from engineering source data with little tailored professional writing, and (3) illustrations are usually developed from equipment design data and do not require action cues.

This discussion implies that some differences in price can be expected between the various JPA formats available, on a per-page basis. Most likely, however, variances between the approaches on a total job basis will be insignificant. The difference between the price of conventional manuals and any JPA of similar scope are quite significant. The bottom line--JPA price--is relatively insensitive to format, once the decision has been made to use a proceduralized approach.

What, then, are the big cost drivers?

Earlier in my presentation, I indicated there are two general categories of variables affecting price. The nature or appearance is one. The other, and by far most significant category, includes all of the circumstances surrounding the JPA development (Slide 12).

CIRCUMSTANCES SURROUNDING DEVELOPMENT OFTEN AFFECT PRICE MORE THAN MEASURABLE FACTORS (FORMAT, MEDIA, DEPTH, ETC.):

- COMPETITION
- UNCERTAINTY
- EXISTENCE AND/OR AVAILABILITY OF HARDWARE
- EXISTENCE AND/OR AVAILABILITY OF ENGINEERING DATA
- DESIGN STABILITY
- PROGRAM TYPE
- PREPARER'S ORGANIZATIONAL PECULIARITIES
- CUSTOMER TYPE (PERSONALITY, KNOWLEDGE, ETC.)
- CUSTOMER TYPE (GOV'T. AGENCY, COMMERCIAL, ETC.)
- TIMING/SCHEDULE

Rahl: Slide 12

The existence and strength of competition affects JPA pricing in several ways. First, the cost to the producer (less general and administrative costs, cost of money, and profit)

is more closely estimated. Fewer contingency funds are included; less project follow-on is anticipated. The low ends of the quoting norm scales are used. Frills are specifically excluded with proposal caveates. Then, within the bounds permitted by the accounting standards, practices, and business objectives, the profit figure is set in a further attempt to develop a competitive price.

Uncertainty is a factor in many programs, particularly developmental programs. Estimators are often asked to price JPAs for hardware that has not yet been designed. There is a natural tendency to assume the worst case under these circumstances, and this attitude is reflected in the estimates. The same problem holds true for other support elements such as test equipment, the design of which is speculative of the prime equipment design.

Of course, this uncertainty does not exist on programs where design has progressed well into full-scale engineering development or production phases. The estimators have the opportunity to examine the equipment or, at least, the drawings. Having the hardware available during the JPA development is extremely beneficial and allows for the best-cost conduct of the job. This is particularly important where the JPA employs a high level of visual cueing. Possession of the equipment allows for actual performance of the task, during which photographs of each cue are taken. Photo-line conversion then provides the most accurate and least expensive illustrations possible.

Availability of engineering data at the right time is very important to cost-effective JPA development. It is an absolute requirement on the many programs where actual hardware availability is limited or nonexistent. In addition, data-dependent analysis, such as head-book tradeoff, level of repair, and others, are impossible without a fair amount of engineering data.

For the most part, the availability of the engineering data is a function of program timing and design stability. Prior knowledge or anticipation of this kind of problem affects the JPA estimator in an obvious way.

The program type can have a dramatic effect on price. Program type refers, for example, to the Air Force buying equipment from a prime contractor where a technical manual is included. In this case, the technical manual could be purchased at a lower cost from the subcontractor, because the prime adds in a certain amount for managing and procuring the technical data. After this markup, the prime will sell the technical data to the government or procuring agency. The technical data end up being high cost items at that point, largely due to extra markup. It may be worth it to the services, however, to have the program managed centrally.

Preparer's organizational peculiarities also affect price. Labor costing methods, driven by the accounting system, result in all or part of the task analysis being charged at an engineering hourly rate or the opposite situation could exist wherein all of the analysis and writing are costed at a lower technical writing hourly rate. Under the worst circumstances, all of the labor types contributing to the JPA development and production could be priced at one rate, well above the expectation for production service labor. Certainly, the method of LSA development (who, where, when, how) will affect cost, particularly where engineering department personnel do the D-sheets, which must then be redone by engineering writers.

An organization whose quality standards are built on years of military experience may not be able to produce JPAs at any other (less costly) level, as might be required to compete in a commercial or foreign market.

Slide 12 has two bullets for customer type, one for the responsible individual person and the other for the customer organization type. In one of the previous presentations, there was a great deal of discussion about the procuring specialist and the need for training that individual. I am amazed at how quickly a naive procurement specialist becomes an expert (in his or her mind) in JPA technology. In a typical scenario, dealing with this individual on an initial contract leaves a lasting impression that will cause follow-on work to be priced accordingly. This is less of a problem where rigid specifications and definitive statements of work exist. The other customer type bullet refers to customer organizational types such as Air Force, Army, Navy, commercial, etc. Costs are always higher on Army JPAs due to multiple reviews by numerous people and use of color; commercial or foreign JPAs may be far less expensive due to less stringent requirements.

Anticipated schedule problems, either protracted or condensed, will affect price. The estimator will accommodate the former by inefficient man-loading and the latter by overtime premiums. He or she will also consider time phasing of the JPA with hardware and engineering data development.

The conclusions (Slide 13) to be drawn from this discussion are that the most important cost drivers on a JPA program are the most difficult to model. Estimates under these circumstances are based in experience and anticipation. While cost models have and continue to be developed, their proper application is in comparative analysis for tradeoffs. In this light, they could serve the useful purpose of the LCC/LSC models whose outputs do not truly represent life cycle cost or logistic support cost, but do show the relative effects of design change options, maintenance concepts, etc.

Discussion

Initial discussion on the detail/number of graphics associated with a user skill level brought out the point that the same type of graphic could be used for an unskilled person as well as for a skilled person. Discussion continued on information type and the format appropriate for different skill levels. It was agreed that, quite often, changes were made as a result of customer preference, given that clear guidelines for text/graphics data format (based upon skill level) do not exist. The use of computer graphics was described as an excellent cost-reducer for "2-D type" graphics (i.e., flowcharts, troubletrees, etc).

During discussion of the usefulness of cost models, mention was made that the models would represent responsibility to someone (i.e., "you want this change--here's how much it will cost"). Further discussion of technical data costs within the life cycle cost of a system led to some controversy regarding the initial-preparation cost relevant to total cost of technical data. Discussion of JPA costs for digital equipment included reference to the fact that repetition of equipment models could be utilized to reduce cost; however, equipment complexity tended to increase cost. Group consensus was that technical manual cost was a significant part of total life cycle costs.

CONCLUSIONS:

- JPA PRICES ARE GREATLY INFLUENCED BY FACTORS OTHER THAN THOSE DEMONSTRATED IN THE APPEARANCE OF THE FINAL PRODUCT.
- THE EFFECTS OF MANY OF THESE FACTORS ARE DIFFICULT TO PREDICT QUANTITATIVELY.
- PRICE MODELS WOULD LIKELY BE OF MOST USE IN PERFORMING TRADE-OFFS (À LA LCC) AS OPPOSED TO ESTIMATING FINAL COST.

Rahl: Slide 13

IMPACT ON JPA PROGRAMS OF SCHEDULES, STAFF RESOURCES, AND CONTRACT REQUIREMENTS

Mr. John Weber
Lockheed-California Company
Burbank, California

[Note. In the initial part of Mr. Weber's presentation--as outlined in Slide 1--he detailed, from a historical perspective, his personal experience with JPA programs at Lockheed-California.]

LOCKHEED-CALIFORNIA COMPANY

JOB PERFORMANCE AID (JPA) PROGRAMS

- CP-140 (CANADA)
  - 92 JPAs
  - 1276 PAGES OF TEXT AND GRAPHICS
  - COMPLETED 1981
- P-3 (NAVAIR JPA PILOT PROGRAM)
  - 10 JPAs (PROP & ENGINE)
  - 219 PAGES OF TEXT AND GRAPHICS
  - COMPLETED 1982
- P-3 (NAVAIR LOGMOD/JPA PILOT PROGRAM)
  - 3 JPAs (AIR CYCLE SYSTEM)
  - 59 PAGES OF TEXT AND GRAPHICS
  - IN-WORK

Weber: Slide 1

When I talk about schedule (Slide 2), I'm really talking to the people from the government here and not to the industry people, because they know what a lot of these problems are. Schedules can control many things and, most importantly, they can control who will respond to an RFQ and even who is going to be the winner. I can get an RFQ in the mail and put together all the inputs from various departments and hand it to a contracts administrator within 2 weeks if I really push. Then, I can sit back for 3 to 6 months and wait for a proposal to go through the finance and contracts mill. The problem is that the relative scope of the money amount for the technical order data is insignificant to the contracts people in relation to the hundred-million-dollar type contracts with which they deal. The fact that I need this funding to continue what I'm doing doesn't make that much difference to them in perspective. So you learn how to plead with these people to get your contract pushed through.

SCHEDULE

- CUSTOMER CAN CONTROL WHICH CONTRACTORS WILL RESPOND TO RFQ
  - TIME AVAILABLE TO CONTRACTOR FOR
    - RFQ REACTION TIME
      - PRODUCTION
      - FINANCE
      - CONTRACTS
  - PRODUCTION DEPARTMENT RESOURCES
      - AVAILABLE PERSONNEL
      - VENDOR AVAILABILITY
  - FORMAT REQUIREMENTS

Weber: Slide 2

I have to think very carefully about the resources that I have. The vendors are difficult to deal with because they typically give you a long time estimate for getting done what you request. I have to look at who is available when costing this out, and I have to look at the average experience level of my people. If I have to bring someone in, there'll be a problem of even finding them because the word is out in the technical writing community that in JPA production you have to follow a very rigid format in your writing. The key is to attract the new JPA writer by challenging him and, then, we have to train him. This training is going to take an average of 500 hours; therefore, it had better pay off. During the training period, we don't expect a lot from the writer in preparing material whether it be intermediate products or the JPA itself. Finally, when the new JPA writer goes to work, you hope for 25 to 35 percent decrease in time per page over the first 6 months. Thus, finding people, keeping them working at a set pace, and finding people that can do this sort of work day after day is very important.

There's another factor affecting our department resources. People have found out that we take a very systematic approach and expect them to produce products that will work. In going through this behavioral task analysis, you can see everything as far as what the writer did, to whom they talk, and how they came up with their writing. When a writer finally goes through the validation process, he must experience getting feedback from a sailor--this feedback may be negative. Another point is that when we have a slight downturn in JPA business, many people jump out of the group. Typically, these people are very successful in other departments.

In regard to Slide 3 and the continuity of JPA programs, this is where it's really at for me. All I'm saying is that, if we (the JPA staff) go out of business, then, it's like "killing

the last of a species." It is very important for me as a developer to have people available who are trained and who have the proper mental attitude required for this kind of work. I don't think the personnel mix is terribly important if you're talking about a new specification or a new JPA program because everybody has to learn that from the start. For the new developer, however, I believe very strongly in on-the-job training. Once you get the writer to the point where he can write successfully, you let him go. Start him working with a task he understands, like changing a spark plug on a car. That training seems to work well, and pretty soon he is able to carry the writing load on his own.

*STAFF

- CONTINUITY OF JPA PROGRAMS
- STAFF SIZE AND MIX
  - RATIO OF EXPERIENCED TO NEW JPA DEVELOPERS
  - JPA DEVELOPER CANDIDATE AVAILABILITY
    - IN-HOUSE
    - OUTSIDE
- TRAINING REQUIREMENTS FOR NEW PROGRAM
  - EXPERIENCED DEVELOPER
    - NEW FORMAT
    - NEW SPECIFICATION(S)
    - NEW USER DESCRIPTION
  - NEW DEVELOPER
    - CLASSROOM
    - OJT
    - INSTRUCTOR SUPERVISOR

* SCHEDULE SENSITIVE

Weber: Slide 3

Slide 4 shows the contract requirements. I believe all these things are sensitive to the schedule. The schedule will decide what happens internally. The level of detail will impact cost to a degree, but will not really cause a whole lot of change. You have to know more details about the system than the level of detail to which you're writing. By source data, I mean that you're starting out with blueprints, existing TOs, and all of the second level or overhaul manuals. I really "press home" to my people that there's no point in not going over and talking to a design engineer and obtaining more source data. The important thing is to put a trail on the source of your information--where it came from. I include in the contract, as part of the Navy's responsibilities, provisions for providing

equipment and personnel for verification and validation. Today, we are very labor-intensive to the point where we are introducing very many errors in the data when corrected. I think that because this production process is such a manual, "people-involved" process, we need some of these machines to get us away from some of these errors.

* CONTRACT REQUIREMENTS

- FORMAT
  - LEVEL OF DETAIL
    - INTERMEDIATE PRODUCTS
    - JPAs
- AVAILABILITY OF SOURCE DATA
- COOPERATION OF CUSTOMER
  - USE OF EQUIPMENT BY CONTRACTOR
  - USE OF CUSTOMER PERSONNEL BY CONTRACTOR
- LABOR INTENSIVE VS COMPUTER AIDED
  - TEXT DEVELOPMENT
  - GRAPHICS DEVELOPMENT
  - PRINT-READY NEGATIVES

* SCHEDULE SENSITIVE

Weber: Slide 4

Discussion

Mr. Weber explained that the 92 JPAs prepared in the CP-140 program were for maintenance "remove-and-replace" type of tasks. Mr. Weber was asked to elaborate on the effects of noncontinuity in JPA program funding. He explained that the JPA team would dissolve and members would be scattered throughout the company. The start-up time and learning curve for a new team would be costly in terms of time and money.

Discussion then focused on the graphics process and different interactions between the technical and graphics personnel at various companies. The use of a graphics coordinator was mentioned as a mediator between the graphics and technical personnel. Quality of the final product was discussed as a significant cost/time element. "Short-cut" production methods of producing art and graphics would quite often be acceptable to the customer, but not to contractor in-house quality assurance (Q/A) people. The extra effort in raising the quality of the product could be substantial in terms of time and money, but have minimal effect on the perceived quality and utility of the final product.

Mr. Weber elaborated on his process of training JPA writers by giving them an initial writing task on a well-known procedure and determining their ability to think and express their ideas in a logical format. He stated that individuals who cannot initially do this usually do not improve to the point of being cost effective. The type of person who excels at JPA writing may be an engineer, ex-flight-line mechanic, or instructor, with no particular background predispositioning successful writers.

ROLE OF JPA ACQUISITION MANAGER

Mr. Reid P. Joyce
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Presentation

It appears that the developers of JPAs have made some reasonable progress towards refining the technology and increasing the probability of accurately estimating cost for what seems to me to be the "simpler stuff," the kind of practitioner tasks that Kay Inaba talked about. I have decided to go back over the notes that I have taken here in the past day or so and highlight things and thoughts that were part of my original discussion.

I'm little bit distressed, although not really surprised, at how much lack of detail has been given to one of the more serious problems--that is, the system acquisition manager. We have spoken pretty lightheartedly here about "hobnailed boots," but have always danced rather gingerly away from the problem as if it's not solvable. I'm not convinced that it's not solvable, although I don't have any definitive answers at the present time.

I'd like to go through some of the presentations given here and highlight some points. Don Finegan started by presenting a study that the Army has currently underway. He tried to see where existing specifications need to be revised, and where they have at least permitted cost and volume excesses within the limits of the existing specifications. During this meeting, several people have mentioned similar experiences with specifications failing to prevent excesses like that. It's clear that, although the specifications provide much guidance, they still permit an amount of stupidity. A JPA acquisition manager who is not particularly experienced either in JPAs or acquisitions can make many errors that are permitted by the specifications.

Sam Rainey talked about the need to get people thinking in terms of system ownership and to educate system acquisition managers in ways of procuring systems that people will use. It's pretty clear that the reward structure in that whole procurement process is not aimed at long-term good. It really does ignore the notion of life cycle cost as affected by the kinds of things that we're concerned with. We really don't have any control over the establishment of JPA requirements that are going to solve the problem of long-term system ownership. As Ted Post says regarding the reward structure, "No good deed shall go unpunished." It's really true that there's no particular motivation for an acquisition manager to direct his efforts at anything besides his own short-term goals. His goals are fairly immediate ones. By the time the appointment of a JPA acquisition manager takes place, so many degrees of freedom have been given away that he really can't affect the long-term good. All he can really do is try to solve his problems within his budget and negotiate a way (whenever he can) to keep from losing his shirt or destroying his career (in the case of a military post).

Ted Post argued in his presentation (as we in the human factors community have been arguing for years) for early involvement of JPA people in the development process so that we can make some kind of positive input to design tradeoffs. If we could make known some of the things that JPAs have to offer to those who have power to make design tradeoff decisions, we could possibly solve some of the long-term system problems in a cost-beneficial way. So far this never happens, although we've been pleading for it to happen for some time. We do tend to get blamed for many system shortcomings of the JPAs and the system (which are not our fault) and it doesn't seem to do much good to "wring our hands" about that.

We've talked about the need for educating the JPA acquisition manager in terms of aspects of JPA technology. I get a little bit frightened of being dragged into the process earlier when I think about how the government decides who is going to be involved in solving the problem. We've said to ourselves that we can't really know how much a JPA package is going to cost unless we have some grounds for scoping it. These grounds come from analyses similar to those presented by Rosemarie Preidis. These analyses are based upon prior knowledge of the size and nature of the system. That only gets you a rough estimate of the cost, however. Again, this is what I thought the main reason for our being here was--how the government could be assisted in developing a cost estimate for a system and being able to argue for the appropriate funds to do the job. Without that kind of scoping material at an appropriate level of detail, how are you going to be able to select a contractor? Maybe that's the wrong approach, but Kay Inaba would argue that there always should have been a several step process. Initially, there's a scoping effort that decides how much the product is going to cost. Then, there's the initial development of materials that will serve as input to the development process. Finally, there's the practitioner who uses his "guaranteed technically accurate" material to go on and produce the JPAs. At that point, the only difference among the potential bidders is along dimensions that we've been hearing about here from people who are presently producing JPAs. These dimensions are the "technique stuff" and automated processing, and they deal with many of the production details. The problems related to scoping in the first place are of such an enormous magnitude that any one of them probably adds up to more than the total difference betwen potential bidders.

As part of the discussion of Ted Post's presentation, Kay Inaba pointed out that whoever uses LSAR sheets complains that the writers didn't know what they were doing and that they never talked to one another. I'm less and less convinced that the single LSAR product is ever going to be useful to all the people who are trying to use it. The training people have needs that are different from the JPA people, whose needs are different from the "engineering type" people. I think that's why we see so much redundancy; it's not just a timing problem. People really do have different qualitative needs that are not satisfied by a single thing like LSAR, and that's why I think we go off and do our own analyses.

Fred Hart pointed out that, as bad as training is, at least objectives are systematically stated for it. This is something that is not really systematically done for JPAs. I guess if we could somehow sidestep this issue of cost, many of us would argue that we should expend our efforts to figure out ways for quantifying performance that we would hope to get as a result of performance aid packages. Then, we could make an attempt to buy some amount of performance per dollar rather than some number of pages per dollar.

Some of the kinds of questions that I hoped we could look at in more detail began to emerge in Fred Hart's presentation. It seems to me that if we look at some of the problems in JPA development that derive from the shortcomings in the technical base that we are using, we could back up and rethink some of the methods for the analyses and the specifications that we are using initially. For example, Fred mentioned that task identification is relatively straightforward. It's important that you identify all of the tasks. What do you do if the people that give you this technical information haven't identified all the tasks, or if they have identified the wrong ones, or there has been some type of mix up? It doesn't take many changes in the number or types of tasks or the proportion of effort that you have to put into these analyses to make a big difference in your cost. So what are the implications of input data, which are usually incomplete to some degree? What if the target audience doesn't turn out to be exactly like the guys that the government told you that you would have to work with? We could identify how

much of an impact such changes would have on cost of developing a whole package for a user group that was different from the one originally prescribed. That would help you decide how much effort you should put into deciding what that user group is going to be. Back in the days of "Vietnamization," we had anticipated working with people who were going to have a year or two of electronics experience and it turned out that they had never seen anything more complicated than a shovel. That had some profound implications for the amount of work you had to put into your package.

How does the procuring agency know how much troubleshooting coverage it's going to get? Many people have talked about that, but I haven't heard anything solid about how we would like to see troubleshooting coverage specified. We used to try to flag every item in the task identification matrix for which we felt that a failure mode effect analysis should be done. Then, we would ignore any failure of the performance aid in finding a system failure that wasn't specifically indicated. This method was utilized for fully proceduralized JPAs. I really don't have any idea how some of the partially proceduralized JPAs would fare in terms of their ability to capture all, or some part, of the failures that occur. So, trying to provide some sort of guidance to you--the JPA buyer--as far as what coverage and types of troubleshooting you want, is something that should be done. I don't think we know how to do that right now.

How good is the built-in test equipment? That topic slid by pretty quickly when it was brought up yesterday. That has some pretty profound implications too. That would provide a real good opportunity for tradeoff if the JPA people were put into the process at the point where JPA solutions and built-in test solutions could be tradedoff. We seldom get brought in that early, though.

Kay Inaba and several of the rest of you have indicated that you are relatively comfortable with your ability to control the costs for JPA generation. You are not comfortable with the customer's ability either to control or guarantee completeness and accuracy of the technical information that comes out of the front-end analyses. I think the point about inadequacy of that technical information implies that we have to create some type of guidance for the analyst-practitioner as opposed to the generator-practitioner--one point, who is that analyst-practitioner and who should he/she be?

Bill Conroy showed us a small scale example of the problems and results of inadequacies in the up-front data. In this case, it was the number of tasks that was wrong and not only that. When the tasks were finally agreed upon, it was discovered that the content of the additional tasks was different from what was originally planned. That kind of thing, I feel, has much bigger cost implications than how you're going to do your graphics. The cost difference in doing a single job resulting from shortcomings in the technical base that you have to work with can be much bigger than the total cost difference resulting from the internal guidelines that determines whether Bill Conroy, with his organization's flexibility, can do a better job at a lower price than Fran Rahl, with his organization's relatively rigid structure and rules.

Rosemarie Preidis' model seems to have much more value for the JPA buyer than for the JPA developer. It seems to me to have value in coming up with a ball-park estimate of the problem that faces you, the JPA buyer. The questions that I have are: At what point should you be trying to implement such a model? When is it reasonable to expect that we'll have a chance to make an estimate like that, talk to the people who are going to control all the system development dollars, and make a pitch for a proportion of that money? It strikes me that we almost always--in spite of the fact that we're talking about JPA cost estimation--"back into the process," knowing how much overall money we have

to spend. We generally have some idea how much money is going to be available for a particular procurement and, although we make much noise about being very careful and quantitative about doing our cost estimate, more often than not we're "backing into it."

Discussion

Mr. Joyce was asked if he thought that BITE could be offset by personnel considerations in a tradeoff situation. He replied that this might happen if the system were understood to the point of specifying what testing the BITE and JPA would be doing. The relative merit of BITE was controversial and, although the philosophy of BITE was deemed worthwhile, the implementation showed that a man-in-the-loop was still required and the possibility exists that BITE could very well make a troubleshooting job more difficult. A point was made that most of the Navy equipment was not amenable to BITE, and electronic equipment only contributed to a small percentage of the total.

Discussion of the acquisition process and problems with ILS continued. Institutionalization of JPA documentation, such as the SPA effort in the Army, was agreed to be a first step in improvement of this process, followed by delegation of responsibility for knowledge of JPA specifications to the system acquisition manager or a permanent staff person.

COMPARISION OF TWO COST ESTIMATION METHODS

Mr. John G. Bean
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Presentation

General Methods of Cost Estimation

There are two apparently different methods of estimating the cost of TI (job performance aids, technical manuals, training materials, etc.): (1) total package and (2) element.

Total Package Estimation. In method 1 (above), the cost of a total package is estimated by extrapolating (on the basis of a complexity ratio or factor) from the actual cost data of a similar package. For example, the cost of the F-18 program is extrapolated from the actual cost of the F-14 program; the cost for an operator manual for the F-18 aircraft is extrapolated from the historical cost for an operator manual for the F-14 program, etc. (see Slide 1).

Element Estimation. In method 2 (above), actual cost of an individual element within the total package is utilized and all the various costs of individual elements are added up to derive the total cost. For example, the cost of a schematic times the number of schematics, plus the cost of an isometric drawing times the number of isometric drawings, plus the cost of a table of text times the number of tables of text, and so forth for all the elements in the package (see Slides 2 and 3).

Convergence of Methods of Cost Estimation. The total package and element methods should lead to identical results when properly applied. Any total package can be broken down into its constituent elements (schematics, functional diagrams, analysis, text, parts lists, validation, edit, etc.) and the cost of a total package prorated among the constituent elements based on a historical cost data base or "engineering judgement."

The following paragraphs discuss some of the key parameters that can affect the TI cost estimating process.

Cost Estimation Accuracy

Cost estimation accuracy boils down to:

1. The accuracy of the comparison (engineering judgment) of a new package to be estimated to a package for which actual cost information is available either on a total package or elemental basis.

2. The accuracy of the actual cost information that has been collected.

Accuracy of Comparing New With Previously Developed Package/Element. Accurate cost estimation is easy if the task to be estimated and accomplished is very similar in structure and nature to a task already accomplished for which accurate historical cost data are available. If an F-18 flight manual is deemed to be about the same complexity as an F-14 flight manual and the F-14 flight manual cost was \$150K, then the F-18 flight manual should also cost about \$150K (providing it is to be developed by the same contractor in a very similar working and cost environment).

Technical Information (TI) Cost Estimation Model

N = Cost of new TI package (see Slide 3 for package example) being estimated

S = Actual cost of similar TI package previously developed (from historical data)

F = Complexity factor (based on engineering judgement)

E = Cost of TI element (Slide 2) in previously developed TI package

$$N = FS \text{ (Total Package Estimation Method)}$$

or

$$N = \sum_{i=1}^{n} F_i E_i \text{ (Element Estimation Method)}$$

$$FS = \sum_{i=1}^{n} F_i E_i \text{ (Convergence of Methods)}$$

F (Complexity Factor) is based on such considerations as:

(a) No. of: LRU's, SRA's, Systems, Functions, Tasks, Subsystems, Modules, Assemblies, Test Points
(b) Increased or decreased capability
(c) Volume
(d) Weight
(e) Amount of Built-in Test (BIT)
(f) Amount of Automatic Test Equipment (ATE)
(g) Amount of Equipment Changes
(h) Actual count of No. of changed or affected pages
(i) Percent of prime equipment cost
(j) Equipment type (electronic, mechanical)

Bean: Slide 1

Examples of TI Cost Elements (1 of 2)

Any complete set may be selected.

A complete set sums to the total TI package. Example of typical complete set: Writing, illustrating, typing, other.

* Writing

Analysis
* Task
* Theory
* Troubleshooting
Research
Planning
Liaison
Source Data
Gathering
* Conversion
Editing
Checking
* Validation
Parts Listing
* Inspection
Rework
* Verification
Supervision

Other Costs

Materials
Travel
Printing
Copies

* Illustrating

Photography
Layout
Inking
Checking
Rework
Half-tone
Exploded View
Line
Cutaway
Mechanical
Supervision

* Typing

Page Layout
Composition
Proofing
Rework
Supervision

Other Considerations

Level of Detail
Maintenance Concept (throw-away versus detailed repair)
No. of LRUs
No. of SRAs
No. of Major Systems, Subsystems Units, Assemblies, or Modules
Schedule
Page Size
Information Density
Program Phase (Research, Development, Test, Prototype, Production)
* Customer Direction
* Equipment Availability

* Cost element which contributes significantly to TI cost and which can be reduced through improved methodology.

Bean: Slide 2

Examples of TI Cost Elements (2 of 2)

Types of Information

Title Page
Warning Page
List of Effective Pages
Table of Contents
Introduction
Federal Mfr Codes and Addresses
Parts List
Numerical Index
Reference Designator Index
Alphabetical Index
Text
- Description
- *Theory

*Diagrams
- Schematic
- Functional
- Test
- Troubleshooting

Procedures
- Operator
- Mechanical
- Test
- *Troubleshooting
- *Logic Trees
- Maintenance Dependency Charts (MDC)

Program Listings
Wire Lists
Check Lists
Lists
- Tools
- Test Equipment
- Materials

* Cost element which contributes significantly to TI cost and which can be reduced through improved methodology.

Bean: Slide 2 (Continued)

Examples of TI Packages

Flight Manuals
Maintenance Manuals
  Organizational
  Intermediate
  Depot
Operator Manuals
Job Performance Aids (JPA)
Fully Proceduralized Job Performance Aids (FPJPA)
Maintenance Requirement Cards (MRCs)
Parts Lists
Illustrated Parts Breakdowns (IPB)
Student Learning Guides
Instructor Guides
Computer Program Listings
Wire List Manuals
Troubleshooting Manuals
Checklists
Publication Indexes
Tape Indexes
Diagram Manuals
Work Package
Job Guide

Bean: Slide 3

The cost estimation situation is much more complex if the previous and new packages are developed by different contractors. Here it's necessary to consider the effect of differences in extraneous factors such as overhead rate, labor grade structure, standard operating procedures, etc. For example, one contractor may do all the writing on overhead and charge directly only for the artwork and typing; another contractor may do just the opposite. One contractor may charge for validation; another may include it as part of the hardware cost, etc. These inherent differences between contractors result in contractors having substantially different prices for what appears to be a similar task.

Historical cost information thus is valid only when applied to very similar circumstances for the same TI developer. This restriction does not apply to procurements in which the effects of extraneous factors are neutralized. For a competitive procurement of a stand-alone package, the total cost should be comparable even though the package is estimated by different developers and the elemental costs vary widely.

In addition, for the estimate to have any real validity, it must have been developed by relating it to a similar job. Whenever new work procedures are instituted or new products are produced, then the initial development may take much more effort than the steady-state repetitive development. (A good rule of thumb is 10:1.) If an organization has never prepared a flight manual before, their first effort may take them many times more effort

than subsequent flight manual efforts. Their estimate for their first attempt would be suspect; subsequent estimates based on their first attempt would also be suspect and probably substantially higher than that at the end of the learning process.

Accuracy of Summing Cost of Individual Elements to Derive Cost of Total Package. Many organizations believe that, somehow, with great masses of estimating detail, they will end up with accurate estimates. This is analogous to believing wrongly that, if the value of something is known to the nearest percent and if all arithmetic is carried out to a thousandth of a percent, the final result will be much more accurate than a percent.

In many cases, the converse is true because so much time and effort are spent worrying about the details that the critical factors become lost in the exercise. A careful and assiduous program of identifying the cost elements and carefully pricing each element out can lead to accurate estimates. But when the level of detail necessary to support the element estimation method is not available or is greatly inaccurate, the mass of backup estimating data produced is of little value and, as indicated above, critical factors are often overlooked in the detail. For example, in estimating the cost of a flight manual, the cost of the command (NATOPS) reviews might be overlooked because the estimator overlooked that a NATOPS conference was required. The total package method would automatically include this cost.

Key Cost Factors In TI Development

The following paragraphs provide a discussion of some of the key cost factors in development of TI. The factors discussed are felt to be those that greatly affect the cost of TI.

Direct Pickup of Source Data. The less writing, illustrating, typing, and editing that has to be accomplished, the less TI development will cost. Conversely, the more rework, reformatting, redrawing, rewriting, and originating that has to be done, the more TI development will cost. A key factor in the cost of TI development is the amount of material that can be directly picked up and the amount that must have substantial rewriting or original writing before it can be used.

One way to reduce the cost of TI greatly is to pick it up directly whenever possible. The government should insist that their equipment contracts require that the engineering drawings, manufacturing and test procedures, specifications, etc. be developed in such a way that they can be used directly in TI. The schematic diagrams in TI should be direct pickup engineering drawings and not be redrawn or relaid out. Similarily, wire lists, program lists, parts lists, and test procedures should be prepared originally for direct pickup in TI. This approach not only greatly reduces the cost of TI, but it also greatly improves quality by eliminating the many transcription errors that are made in reprocessing source material.

Level of Detail. TI must be written to the level of the intended user, eliminating all unnecessary detail above or below his level, but provide enough information so the user can do his job without error.

1. If the user knows how to use a tool or item of test equipment, then procedures merely need words to the effect, "Using (tool or test equipment item) . . . ."

2. If the user does not know how to use the tool or test equipment item, detailed step-by-step procedural information is needed either in the specific procedure or by reference to another procedure.

3. If the user has developed a skill or learned the knowledge in his training course, then explicit information should not be given but should be assumed to be known by the user.

4. If the user has not mastered the skill or cannot recall knowledge from memory (i.e., as the result of a training course), step-by-step instructions or detailed information will be necessary.

During the writing process, the minimum amount of detail thought necessary should be developed. If, at validation, it is found that the information is not adequate for the user to do the task the first time without error, then additional information can be provided and revalidated.

One of the functions of job performance TI is to provide a reference document where the user can go if he has questions about his procedure. So, even for a task where the user would normally be expected to know all the detailed steps, it still may be necessary to provide the detailed reference procedure in the job performance document. The ultimate test of the level-of-detail match is a demonstration that a user with aptitude, training, and knowledge equivalent to that of the intended user can actually perform the necessary tasks without error.

Thus, there is a tradeoff between TI and training. With additional training, the user will need less information in his TI documents and vice versa. In general, this tradeoff must be accomplished for each individual program. Training is a recurring cost and TI is a nonrecurring cost. Where large numbers of technicians are encountered, it may be cheaper to include the necessary information in the job documents, rather than to provide an extensive training program. On the other hand, with limited quantities of equipment and small numbers of technicians, then an extensive training program may be the most economical approach.

<u>Analysis</u>. One of the highest cost factors in TI development is engineering or analysis effort. This includes task analysis, theory-of-operation preparation analysis, and troubleshooting-procedure development analysis.

1. <u>Task analysis</u>. Task analysis is becoming increasingly important in TI development. Prior to the presentation-of-information-for-maintenance-organization (PIMO) program, task analysis was given little emphasis by TI developers. Properly carried out task analysis leads to better TI, developed at lower cost because the proper tasks are included in the technical document with the right level of detail; extensive rework and modification to compensate for a poor task analysis are unnecessary.

Potentially, logistic support analysis records (LSARs) are a valuable task analysis information source for TI generators. However, the process by which LSARs are currently developed and documented is not TI oriented. Shortcomings in the LSARs seriously impair their value for TI task analysis. As a result, in many cases, a separate duplicative analysis is carried out specifically for TI generation. A concerted effort should be made to integrate the LSAR analysis outputs for direct use as the task analysis baseline for both the training and TI development process.

2. <u>Theory-of-operation analysis</u>. Theory of operation has the objective of supporting troubleshooting by providing information that enables the technician to understand the equipment and figure out (from his understanding) how to fix it. Ordinarily, theory of operation is not presented in a job context where it is related to a specific job task but, rather, as general information somehow applicable to all tasks.

Since a highly skilled, subject matter expert is required to write the theory of operation, its cost is usually high. Because personnel of this capability are in short supply, usually the theory material is inaccurate and incomplete.

Conventional theory formats usually provide little information except the obvious: Signal x is applied to component x, which generates a new signal y and applies it to component y, etc. In most cases, the theory of operation is extremely difficult to read and understand and adds significant volume to the technical document.

In the conventional approach, textual material is intended to convey all of the essential information. Several new methods are available that greatly improve theory of operation, reduce the cost of its development, and reduce its volume. These techniques use the block, functional, or schematic diagram as a basis and then key the textual material specifically to the diagram.

3. Troubleshooting procedure development analysis. Troubleshooting procedures are the most difficult part of TI to develop and are, thus, very expensive. Computer-developed troubleshooting promises to provide a means to reduce significantly the cost of preparation of troubleshooting information and also provide much higher quality troubleshooting information.

Computer-developed troubleshooting enters a model of equipment in a computer data base and then allows the technician to input test result information. A computer program then processes the test results, determines the next test for the technician to make and enter results about, and so on, until the trouble has been isolated. This type of troubleshooting does not rely on technician understanding of, or knowledge about, the equipment in order to fault isolate, so requirements for theory of operation and other troubleshooting type of information in the TI document are minimized.

Computer-aided Authoring. Substantial reductions in TI development costs can also be achieved by the application of computer-assisted authoring. Computer-assisted authoring prompts a subject matter expert (who is usually not an expert writer or instructional technologist) to input source information that is then automatically formatted and processed into the final TI document. Utilizing computer data bases for vocabulary, spelling, tools, nomenclature, etc. can greatly reduce the burden on the writers and editors, the inconsistencies within and between technical documents, and greatly increase TI writer productivity.

Illustrations. Another high cost item in TI development is the preparation of illustrations. One reason for the high cost of graphics is overspecification of requirements. These overspecifications include the following:

1. Requiring too much detail; overelaborateness.
2. Requiring too much fidelity.
3. Overemphasis on angle of view.

Computer graphics promises to reduce cost of illustration development greatly by increasing productivity of artists. It still will be important to review the contractual specifications to assure that unnecessary requirements are not imposed and that illustrations contain only the bare minumum of detail necessary to portray the intended information clearly.

Source Data Accuracy. Accuracy and availability of source data (such as engineering drawings, test specifications, test procedures, etc.) greatly affect TI cost. The following are typical source data problems:

1. Inaccurate or incomplete.
2. Continual change.
3. Late release or incorporation of changes.

When the engineering source data are not available or rapidly changing, the TI writing process is in a constant state of change and confusion. In some programs, this is necessary due to the high priority of getting the equipment out to the field as rapidly as possible. However, in most programs, adequate planning can minimize the impact of this change process. It may be well in rapidly changing programs to recognize the situation and turn out the document in an evolutionary manner. (For example, deliver the essential procedural information, the schematic and functional diagrams, the troubleshooting procedural data, and so on.)

Customer Direction. Changes in direction by the TI customer can be another major cost factor. In some cases, this comes about because the contracting officer's representative is reassigned in the middle of a program causing a new representative to be assigned who then brings his own viewpoints to the project. In other cases, it is simply a matter of subjective change of direction that causes extensive rework and high associated costs. In many cases, agreeing on a baseline sample early in a program or including a sample of the desired product with the request for proposal will greatly clarify customer requirements and minimize changes in direction. The following are some examples:

1. Change of mind.
2. Inconsistent direction.
3. Subjective comments.

Equipment Availability. When the equipment is available, the TI preparation task is greatly simplified and, consequently, costs can be greatly reduced. Instead of the writer or artist having to guess about an aspect of the equipment or trying to figure it out from the engineering drawings, he can get up and go over and look at the actual equipment, take a photograph, make a sketch, etc.

Similarly, in the validation process, it is essential that hardware be made available to support the test of the TI validity. If the equipment is not available for validation, the procedural information will just not be accurate.

Data Entry. The conventional way to develop TI is for the writer to prepare a draft of the material in long hand, give it to a typist who prepares a typed draft and returns it for review, make corrections, and send it back to the typist for correction. This process continues until the document is finalized.

This process is both time-consuming and costly. Many TI developers soon will greatly increase the productivity of the data entry process by placing data entry terminals in the hands of the technical writers who then enter the data, make the necessary revisions and corrections, and print out the final copy without ever utilizing the services of typing or production personnel. It is also expected that many TI developers will combine this process with computer-developed graphics so that the entire TI document production process is essentially automated.

Problems Associated With Utilizing Cost Per Page

In preparing and evaluating proposals, contractors and the customer (government) need easily identified elements against which to associate cost. Pages, frames, illustrations, data modules, etc. are examples of such units. The existence of much valid historical cost data based upon these units further strengthens the argument for their continued use in pricing.

There are problems associated with the use of these units for pricing, however. On one hand, the contractor, in order to maximize his profit, desires to bid the maximum number of units against which cost can be legitimately associated at the maximum cost per unit. On the other hand, the government, in an attempt to keep program costs as low as possible, strives to keep the total number of units and the TI unit cost to a minimum.

In many cases, unfortunately, the result of this interplay is too much emphasis on the unit cost and not enough on the total number of units. In order to actually reduce the number of units, considerable effort is required on the part of the contractor to edit, relayout, and otherwise condense the information. When the government is overly sensitive to a cost per unit, the contractor is reluctant to take on the extra effort that, in fact, will increase his cost per unit without compensation. In fact, he is penalized because of his higher cost per unit than less consciencious contractors and he may be held up to be a "high per-page-cost" contractor.

To alleviate these problems, both the contractor and the government must adopt the attitude that TI units are only a means of determining a price for level of effort associated with production of a TI package. The government should not buy a definite number of units but, rather, an effort that will produce the minimum number of units needed to accomplish the purpose of the TI. The contractor must be adequately compensated for cost incurred for the additional effort associated with the reduction of TI units, and a higher cost-per-unit should be expected and encouraged when the total number of units is reduced.

Recommendations

1. Direct pickup of TI source data. Drawings and other source data should be formatted initially so that they can be used directly as TI.

2. Logistic support analysis records (LSARs). LSARs should be prepared in formats that can be directly used for TI task analysis.

3. Computer-assisted troubleshooting (CAT) development. CAT development and use should be encouraged to reduce TI development costs and improve the quality of troubleshooting information presented to the user.

4. TI volume reduction. A specific contractual obligation (task) should be required. The contractor should have a contract task to review and boil down the information to the minimum essential TI. This task should be funded and adequate time allotted for its completion.

5. Computer-assisted authoring (CAA). CAA should be encouraged as a way to improve author productivity and TI quality.

6. Sample of desired product. The customer should include a sample of the desired product as part of the request for proposal. This sample will greatly clarify how the customer will interpret the TI specifications and facilitate accurate cost estimating.

7. Equipment availability. Programs must be more carefully planned so that hardware/equipment will be available for TI writing and validation. This may result in equipment stretchouts or the requirement to purchase additional equipment early in a program.

Discussion

Initial discussion of Mr. Bean's models focused on the models' utility and identification of a point at which the difference between old and new systems made historical information nonapplicable. The group agreed that it would also be nice to have operational and maintenance data on the historical system. Discussion of differences between contractor's costing methods brought out the difficulties in comparing contractor costs. The problem of the "submersion" of technical manual costs within hardware and total system costs was discussed. Mr. Bean mentioned one company that includes the entire cost of technical manuals in their overhead. Although discrepancies were noted between companies, Mr. Bean noted that, to some degree, comparison between companies was possible, but the comparer must be aware of company-peculiar costing methods.

Discussion then centered on the cost and time savings attributable to computer-aided authoring, illustrating, text editing, etc. A point was made that fewer errors occurred in the text when computer aiding was used, with resulting reductions in validation time and easier editing/revision of revised materials.

Discussion also covered the level of detail necessary for the task analysis. Mr. Bean stated that the detailing of steps within each task was not necessary and that the information for task analysis should come out of LSA, with the exception of specific steps involved in each task.

ANALYSIS, CONCLUSIONS, AND RECOMMENDATIONS

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The major objectives of the JPA cost factors meeting were to identify factors that influence the cost of job performance aids, present current methodologies for cost estimation, and develop preliminary cost modeling ideas with some direction for future research. This information would be used by NAVPERSRANDCEN to highlight areas that might be defined further and assigned some priority for research.

Certain limitations on the scope of the meeting were defined early. The technical information type was limited to job performance aids, and this was further restricted to a paper-domain. Booher's (1977) statement that "there is no generally accepted definition for a job performance aid--even among those who have done considerable research and development in the field" was "revalidated" during this meeting. Initial controversy over the weighting of JPA cost versus JPA effectiveness cast some doubt about attaining this conference objective. Fortunately, despite differing philosophies concerning the definition of JPAs and the importance of cost estimation, some valuable information was shared by conference participants.

The presentations can be sorted into two groups: (1) Those concerned with cost estimation models (quantitative), and (2) those concerned with identification of JPA cost drivers (qualitative). Two presentations emphasized information of the first type; all presentations contained some information of the second type.

JPA Cost Estimation Models

Ms. Preidis presented a specific methodology and Mr. Bean discussed two types of cost estimation methods. Ms. Preidis' model predicted page numbers for 12 different page types using system characteristics as cost factors. The cost of producing each page type is estimated and these elements are combined to yield a total cost estimate. Her method corresponds to Mr. Bean's "element cost estimation" method. Another method described by Mr. Bean was the "total package estimation" method by which historical cost data from a similar system are subjectively "inflated" to obtain an estimate for current systems. The general group consensus was that these models are good for rough, but not accurate, estimates. Indeed, the remaining factors not contained in these models are numerous and substantially contribute to final cost. Thus, for systems with some historical precedent, with similar preproduction factors, these models may offer utility to the procurer. It seems that these models will be restricted to production cost estimates, in terms of accuracy, given the variability and impact of front-end costs.

Mr. Bean suggests that a limited number of cost-per-page categories be chosen for a select group of document types. An example of a standard for a hybrid JPA (double-column, single-spaced, 10 percent foldout pages of 3 units average) might be as follows:

Hybrid JPA

Cost Category		Cost per Page	
a.	Writing	7 hrs	
b.	Illustrating	5 hrs	
c.	Typing/Production	2 hrs	
d.	Inspection	1 hr	
e.	Validation	2 hrs	
f.	Material		$5.00
	Total cost per page	17 hrs	$5.00

Mr. Bean stated that there would be wide but not complete application for such standards. Contractors would have to establish fairly elaborate accounting systems in the cost-per-page categories in which to collect cost data for each document type. Mr. Bean considered it possible to do this for a simple system, as shown in the example. For a system such as the one described by Ms. Preidis, he considered the cost accounting system to be impractical at this level of detail.

Thus, it appears that the cost modeling techniques described by participants may have some utility for production cost estimation. The accuracy of such methods will depend upon the stability of the front-end data preparation process. Until the front-end process can be stabilized, cost estimates for overall project cost will remain a "hit-or-miss" proposition. Each TI preparation project, even those for the same document type, will remain an entity unto itself, influenced by unique combinations of unaccounted cost factors that are not comparable to a current effort because the producer and procurer cannot be certain which random variations in these factors will affect current costs.

Identification of JPA Cost Drivers

Qualitative information presented during the meeting covered various subsystems within the JPA preparation system. Preparation system is used to connote the entire life cycle of a JPA, from the initial technical information requirement to the final delivery. Figure 1 has been prepared to show a general JPA life cycle in which major cost factors can be subdivided and placed. Six major development phases are shown with three participant groups. Cost milestones include the weighing of budget constraints versus system needs, initial cost estimates, budget definition, and final cost before and after a product-fix phase. Further costs may be involved when system updates necessitate JPA data updates.

A major point emphasized during the meeting was the discrepancy between the ideal and usual budget development process. The ideal process involves the definition of user needs and specification of proper TI to meet those needs. Budgeting then involves the fitting of a cost estimate to the data collection process and TI preparation (i.e., effectiveness first, cost second). The usual budget development sequence followed is (1) allocate budget, (2) define what can be done for the allocated dollars, and (3) try to make that meet user needs (i.e., cost first, effectiveness second). Although Figure 1 is an accurate reflection of the preparation process as described in various DoD documents, it represents the ideal rather than the usual, probably because the usual looks even worse when shown in print.

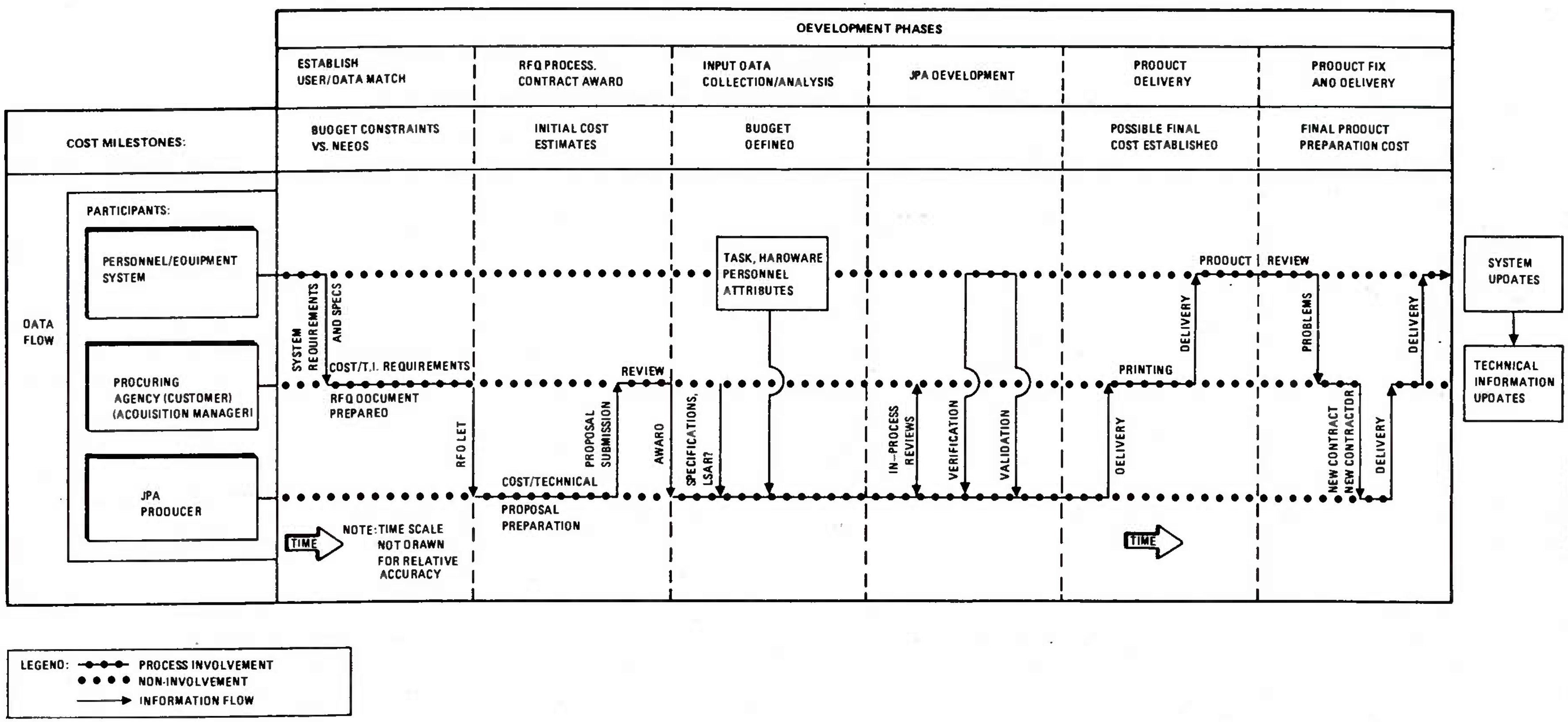

Figure 1. Job performance aid preparation process including competive bid/producer collection of input data.

Figure 1 is prepared to allow for a system framework in which the cost factors can be contained; however, one must recognize that all the variations of this process cannot be shown and must be incorporated by the reader. Points of difference may include situations where there is a noncompetitive bid, input data are prepared by the procurer, input data are fixed by the preparer, validation is done by the procurer, and no product-fix phase exists.

While many cost factors were identified, conference attendees focused on those related to cost milestones and to the participant characteristics that affect cost. The various cost factors were subsequently grouped into one of seven areas, identified in Table 1. Each area was subsequently broken down into the individual factors. These factors and attendees who stressed each are presented in Table 1.

The number of dots in the Table 1 matrix should not be evaluated as indicating factor importance, as each participant chose to focus his or her attention on different development phases and factors. Table 1 also contains cost-reduction suggestions voiced during the meeting and items that drive up cost or increase variability in cost estimates. Each cost-factor area is discussed separately. Interactions between factors, however, must be recognized as they may create other cost problems.

Cost Factor Areas

Personnel/Equipment/Environment Characteristics

These factors include physical characteristics and attributes of the personnel, equipment, and environmental conditions in which they operate. Equipment characteristics are more numerous than those shown in Table 1, but these were most frequently mentioned during presentations and discussions. A difficulty in summarizing group opinion on most important cost elements such as these results from the difference in the level of detail at which each participant presented their cost factors. Some overlap of factors is unavoidable; for example, the "amount of BIT" is a detailed factor associated with a more general factor, electronic "equipment type." This overlap may be useful, however, given the variability in the amount of detail for information available on a given system at various stages in development. For example, one may only know that a certain percentage of equipment will be electronic and not the amount of BIT to be incorporated, at the time a JPA cost estimate is made.

"Equipment type" includes mechanical and electronic systems. Although the group agreed that mechanical systems outnumbered electronic ones (for the Navy), electronic systems received much more discussion emphasis. The inclusion of troubleshooting tasks was determined to influence complexity and cost of JPA production significantly. Although BITE and ATE were offered as hardware aids for troubleshooting tasks, limitations of these alternatives showed that we are a long way from eliminating a man-in-the-loop. Dr. Inaba indicated that a 65- to 130-percent page increase could be expected for troubleshooting tasks. Improvement of front-end analyses and computer-aided maintenance were offered as troubleshooting JPA cost reducers. Hardware repetitions and symmetry were noted as electronic equipment characteristics that could be capitalized upon in reducing JPA preparation costs.

Table 1

JPA Cost Factors, Cost Reduction Suggestions, and Cost-Variability Drivers Tabulation

COST FACTOR AREAS	FINEGAN	RAINEY	POST	HART	INABA	CONROY	PREIDIS	RAHL	WEBER	JOYCE	BEAN	COST REDUCTION SUGGESTIONS	HIGH COST/COST VARIABILITY DRIVERS
① PERSORREL/EQUIPMENT/ ERVIRONMENT CHARACTERISTICS													
A. RUMBER OF LRU'S			●				●				●		
B. RUMBER OF SRU'S			●				●				●		
C. TROUBLESHOOTING TASKS				●	●			●			●	• IMPROVE FMEA AND DEPENDENCY ANALYSIS OF ILS PEOPLE • USE COMPUTER BASED/GENERATED DATA	• 65–130% PAGE INCREASE TO BE EXPECTED
D. EQUIPMENT TYPE								●			●	• TAKE ADVANTAGE OF SYMMETRIC HARDWARE AND LIKE ITEMS	
E. AMOUNT OF BIT			●	●							●	• INCREASE TO A POINT–DECREASES JPA TASKS	
F. AMOUNT OF ATE				●							●	• INCREASE TO A POINT–DECREASES JPA TASKS	
G. PERSONNEL SAFETY					●							• CONSIDER PERSONNEL EXPERIENCE	
H. SUPPLY SYSTEM, WORK STATION DISTANCES, ETC.					●							• CONSIDER WORK ENVIORNMENT–ACCURACY REDUCES VALIDATION	
② PROCURING AGENCY ATTRIBUTES													
A. TIMING. NEEDS SPECIFIED EARLY		●		●									
B. CUSTOMER CHARACTERISTICS		●	●	●	●	●					●	• EDUCATE AQUISITION MANAGERS	• PERSONALITY, KNOWLEDGE • GOVERNMENT/COMMERCIAL CUSTOMER • CHANGE OF CUSTOMER MIRD/DIRECTION
C. PROJECT SCHEDULE SPECIFIED											●		
③ JPA PRODUCER ATTRIBUTES													
A. OVERHEAD/MATERIALS TRAVEL/PRINTING				●					●		●	• LOCAL EQUIPMENT AVAILABILITY	• NON–COMPARABLE OVERHEAD PRICING AFFECTS PROPOSAL COMPARISONS
B. ORGANIZATIONAL STRUCTURE								●	●				• RIGIDITY MAY INHIBIT NEW, COST–CUTTING PROCEDURES
E. STAFF EXPERIENCE LEVELS		●		●					●			• CONTINUITY OF JPA PROGRAMS – INSTITUTIONALIZE JPA'S IF APPROPRIATE FOR SYSTEM	• USING TRAINING PEOPLE TO WRITE INCREASES COST & QUALITY
④ JPA CHARACTERISTICS													
A. LEVEL OF DETAIL						●		●	●		●	• KNOWN BEFORE RFQ WRITTEN • REDUCE FOR SIMPLE PROCEDURES	• OFTEN DONE TO AN UNECESSARY LEVEL
B. ILLUSTRATION/GRAPHICS TYPE/DENSITY	●						●	●	●		●		• USE OF LOCATOR VIEWS, HUMAN FIGURES, ETC • USE OF BLOCK DIAGRAMS, SCHEMATICS, MDC'S REQUIRES SKILLED WRITERS/USERS • SOURCE DATA QUALITY AFFECTS WORK REQUIRED
C. VOLUME	●	●					●	●		●	●	• INCLUDE VOLUME REDUCTION REQUIREMENT IN T.I. CONTRACTS • USE PERFORMANCE–BASED JPA'S	• PERFORMANCE–BASED JPA'S–COSTLY TO VALIDATE/SPECIFY CRITERIA
D. FORMAT	●			●	●		●	●	●		●		
E. PAGE SIZE/INFORMATION DENSITY/COLOR	●										●		• USE OF COLOR EXPENSIVE
⑤ RFP/BIDDING PROCESS													
A. MOTIVATION FOR ACCURATE COST ESTIMATES					●				●			• ESTABLISH NEW POSITION FOR TI MATERIALS AQUISITION	
B. RFP SCHEDULE								●	●	●		• UTILIZE BIDDERS CONFERENCES/FREER SCHEDULES	
C. RFP FORMAT											●	• INCORPORATE WORK SUPPLIES IN RFP • BID PRODUCTION/UP-FRONT WORK SEPARATELY	• UNCERTAINTY INTERACTS WITH CUSTOMER CHARACTERISTICS TO DRIVE UP COSTS
⑥ INPUT DATA QUALITY													
A. SOURCE DATA AVAILABLE		●		●	●	●	●	●	●		●	• DIRECT PICK–UP BY CONTRACTOR FROM DRAWINGS, SPECS, TEST RESULTS	• REFORMATTING, REWRITING, COLLECTION, ETC. DRIVES UP COST
B. SOURCE DATA ACCURATE		●		●	●	●				●	●	• ORIGINATE DATA FROM DISCIPLIES TRADITIONALLY ASSIGNED TO COMPLETE IT • QUALITY SHOULD REST WITH CUSTOMER	• LSAR DATA AVAILABLE? • LATE RELEASE/CONTINUAL CHANGES
C. TASK/OPERATION THEORY/TROUBLESHOOT ANALYSES				●	●	●	●	●	●	●	●	• USE LSAR INFORMATION DIRECTLY • USE TASK ID MATRIX • IDENTIFY PROPER DETAIL FOR TARGET POPULATION	• LSAR OFTEN DONE POORLY • LSAR NOT APPLICABLE FOR TECH. INFORMATION PRODUCTS
D. EQUIPMENT AVAILABILITY				●		●		●	●	●	●	• SPECIFY AS PART OF PROGRAM PLAN	• POOR QUALITY SOURCE DATA COMPOUNDS PROBLEM OF EQUIPMENT NON–AVAILABILITY
E. MAINTERANCE CONCEPT						●					●		
F. PROGRAM PHASE				●		●		●			●	• WITH NEW EQUIPMENT PLAN FOR T.I. UPDATES AND MAINTAIN T.I. DEPT./ENGINEERING RAPPORT	• NEW OR EXISTING EQUIPMENT SIGNIFICANTLY EFFECTS COST • PERSONNEL NOT FAMILIAR WITH NEW EQUIPMENT
G. VALIDATION/VERIFICATION	●			●		●			●		●	• REDUCE VERIFICATION SCOPE • IMPROVE VALIDATION • LOCAL PERFORMANCE • CUSTOMER MAKE PERSONNEL AVAILABLE	• SAMPLE SIZE/AVAILABILITY OF SUBJECTS
⑦ JPA PRODUCTION PROCESS													
A. COMPUTER–AIDED AUTHORING					●				●		●	• REDUCTIONS IF UTILIZED	
B. WRITER COMPUTER ENTRY/OR TEXT PROCESSING		●			●	●			●		●	• REDUCTIONS IF UTILIZED	
C. COMPUTER–AIDED GRAPHICS		●		●	●				●		●	• REDUCTIONS IF UTILIZED	
D. GOVERRMENT SPECS	●			●	●			●			●	• ELIMINATE UNNECESSARY SPECS ON ILLUSTRATIONS	• UNSURE SPECS AND FEAR OF PROBLEMS INFLATES COST ESTIMATES • MISINTERPRETED SPECS INCREASES COST/VOLUME • PROBLEMS WITH READABILITY FORMULAS, WRITING RULES, STANDARD WORDS
E. CORTRACT MONITORING		●		●					●				• LACK OF PROPER IN-PROCESS REVIEWS AND START-UP MEETINGS

Personnel experience level or prior training were not mentioned as factors, although they were implied in the "personnel safety" element. The unspoken rules covering user/data matching were demonstrated in Mr. Rahl's examples of JPAs for various user skill levels. It was mentioned that certain graphics are usually thought of as being applicable to either experienced or inexperienced personnel; however, operational experience had not shown significant performance changes when the rules were not followed. Thus, the validity question concerning commonly used user/data matching rules was raised but, for the most part, avoided. The group agreed that a certain format could be specified as "best" for a given user group, although this decision was not accepted as easy to do in practice.

For this cost area, troubleshooting tasks received the most discussion as a cost element and, specifically, troubleshooting with electronic systems. Clearly, the group identified the methodology in this area as a target for continued research, with need for improvements in guidelines for cost/effectiveness tradeoffs related to presentation methods (especially graphics).

System attributes, such as number of LRUs, SRUs, subsystems, etc., were selected as factors within page estimation algorithms. These attributes may offer some utility as "easy to measure" variables, given that they can be shown to be associated with TI complexity/volume.

Procuring Agency Attributes

Participants who addressed "customer characteristics" as a driving cost factor agreed that this factor was the single biggest cost inflator. Contractors all had stories about lack of direction and personally biased tradeoff decisions emanating from systems acquisition managers. Participants voiced their feelings that the specifications were good, but not properly implemented due to the influence of these managers and the ignorance of procurers. The institutionalization of JPAs, such as in the Army SPA program, was viewed as a first step in reducing the negative effect of these project managers. Education of acquisition personnel was determined to be critical. Mr. Joyce stated that a responsible position has to be implemented, one with authority and knowledge to implement the specifications properly. This person would be responsible for obtaining maintenance performance per dollar and considering the effects of JPAs on long-range system costs. The general feeling of frustration voiced by the group was that we could have the best specifications in the world concerning JPA production; however, we are at the mercy of decision-makers who are making cost tradeoff decisions while paying more attention to procurement budgets and personal feelings, with system effectiveness and specification directions considered as an afterthought.

To develop these criteria, the methodology for quantifying JPA cost impact elements has to be strengthened to provide better direction for cost/effectiveness tradeoff decisions. In addition, the acquisition manager has to be made aware of the results of this improved JPA methodology. The latter is necessary if the first is to have any impact.

JPA Producer Attributes

General agreement was that differences among producer-specific cost-estimation methods increases the difficulty of comparing bidders' proposals by a procurement agency. These producers' idiosyncrasies do not significantly affect final product cost, however. Mr. Weber concentrated his presentation on the problems of developing and maintaining a successful JPA production staff. Mr. Bean pointed to overhead costs as a significant

proportion of overall costs. These cost factors were generally viewed as facts of life or company-internal factors. In relation to other cost factors, it seemed that the majority of attendees would downplay the relative importance of company peculiarities in JPA production costs with procuring agency characteristics and front-end analysis problems far outweighing these factors. While producer factors appear to have some cost influence and the procurer should consider each bidders' production-staff experience, these factors don't appear to be a prime target for immediate study/efforts for cost reduction/prediction.

JPA Characteristics

These factors include the physical attributes of the printed JPA materials. As Figure 1 shows, these characteristics are (or should be) defined in the early development phases of a system. The type of format chosen is generally thought to be dependent upon task variables, user skill level, and working environment. Dr. Smillie noted that we still don't have good performance data to support these format tradeoff decisions. It appears uncertain, however, how much cost impact these JPA characteristics have on overall cost. Mr. Rahl compared the overall JPA cost to an iceberg with a small portion visible above the water. The visible portion represented the attributes of the final product that were clearly visible--number of pages, density, format, illustrations, color, etc. The submerged iceberg portion represented other factors such as cost areas 2, 5, and 6 in Table 1. Thus, once a format decision is made and the input data collected, the cost of the process of turning this information into a meaningful format varies little as a function of format chosen in relation to overall cost variability caused by other factors. Production costs are becoming increasingly controlled with the use of computer-aided text processing, graphics, and authoring.

These cost factors will inevitably find their places within cost estimation models but, as this conference group has indicated, the models with a sole focus on product-attribute variables will generally yield ballpark figures and the majority of the cost variability will be uncontrolled as a result of the submerged factors. Group consensus was as follows: Given two sets of physically similar JPAs produced by the same company, you could likely have a large cost difference due to the variability in the path that was followed from the initial JPA requirement to the final product. To the extent that cost variability for the submerged factors can be reduced, these more easily measured JPA attribute factors will emerge as useful cost predictors.

RFP/Bidding Process

The first factor includes the preparation of the RFP and the JPA producer proposal response. Vagueness and uncertainty at this point were noted by all contractors as commonly found customer attributes. Quite often the customer isn't sure what he wants or needs but, when the final product begins to become a physical entity, the customer realizes that the product is not what he wants. The suggestion that a work sample be included in the RFP would certainly help reduce this uncertainty.

It was apparent that the majority of customers do not know how to utilize specifications and translate their ideas into written JPA requirements during early phases in the development process. Efforts such as that described by Mr. Finegan are aimed at creating better guidelines for contract monitors. Clearly specified project goals, at this point, can direct effort toward a final product with minimal wasted energy/money. Uncertainty was identified as the frequent enemy of budget directors, procurers, and producers alike.

A question often raised during the meetings was the location of responsibility for accurate cost estimates at this point in time. At this point, the preparer and buyer are trying to estimate costs from the viewpoint of how much money is available, and what technical data can be created to fill the void. The conference participants voiced concern over this backwards method of JPA material proposal preparation, but could offer no positive solutions to this complex problem. Even if the motivation existed in all parties involved for buying a certain level of performance with TI dollars, current state of art in the knowledge of cost-format-performance relationships prohibits one from taking that attitude.

Other suggestions for RFP process improvements relevant to cost control included bidding conferences, freer response schedules, and separation of front-end production costs. The impact of the last suggestion on overall costs depends upon the type and quantity of front-end work the sponsor expects the contractor to do (or redo). This must be considered in the RFP statement.

Mr. Weber explained how the RFP schedule can place contractors out of the market when interactions of schedule and certain corporate characteristics occur. The bottom line for the contractors, at this point, was that they'll do whatever the procurer specifies in the RFP, but the consequences of poor input data and changes in customer direction will greatly increase cost or result in a poor quality product. Project direction in terms of observable goal, work samples, knowledge of front-end data quality and requirements, user/data match guidelines will increase the accuracy of preproduction cost estimates, and shift the cost variability to the production process phases.

Input Data Quality

The quality of the input data, the process of collection, and the availability of data sources were probably the most talked about factors during the conference. Dr. Inaba pointed to the input data validity as one of two major cost determinants. He felt that the responsibility for quality input data lies with the procurer and too often the JPA producer has absorbed the responsibility for correcting poor quality data. Regardless of where the responsibility lies, everyone agreed that current LSAs are not providing it at sufficient quality levels. Arguments about whether the problem should be fixed under the LSA umbrella or whether a separate effort was needed continued for some time during Mr. Post's presentation. The group agreed that LSA is here to stay and that something should be done to make its products better suited for technical information preparers. It seems that much of this deficient quality results from the LSA trying to be everything for everybody. The logistics problem, by whom and when the data are collected, was stressed.

Improvement suggestions offered were as follows: Prepare source data in suitable format for JPA producer pick-up, originate data from disciplines traditionally assigned to complete it, improve LSA in Project Hardman context, and specify equipment availability as part of the program plan. The group consensus was that someone must be responsible for these data; most often the data need to be reconditioned. The procurer must be aware of the need for quality data and be prepared to accept the responsibility for quality or be willing to spend more money for contractor collection of this data.

Although verification/validation occurs later in the development process, they are arbitrarily included in the "input data" factors as they are a form of information transfer from the system to the producer. Discussion of the task sample size, subject availability, and subject sample size led to a group consensus that: (1) Subjects should be selected

from the target population, (2) a high percentage of tasks (at least 95%) should be validated, and (3) these items should be specified in the contract. Producers were nervous about cutting corners during validation/verification in an effort to cut costs. Despite relatively high costs and difficulty, the accuracy of validations and generalization of these results to a "real world" implementation of the JPA were seen as too important to reputation and JPA acceptance to risk a reduced verification/validation effort.

JPA Production Process

Contractors generally felt that they had control over cost variability for the JPA generation process--writing, illustrating, editing, etc.--and computer aiding of the labor-intensive areas was unanimously acclaimed to be the precursor to tightened cost control. Some overregulation by government specifications was indicated as causing too much detail in text and overelaborate illustrations. Contractor-procurer communication problems during this process, including poor start-up meetings and lack of proper in-process reviews, were acknowledged.

Production costs are not inexpensive. Group consensus was that they do not significantly contribute to differences between final costs and initial cost estimates. Given a prescribed set of front-end conditions, including quality input-data and format requirements, the procurer can be reasonably assured that the cost estimate for production will be accurate. Separation of production costs and up-front costs was again voiced as a practical solution to many cost control problems.

JPA Cost Factors Summary

Table 1 also addresses major contractor characteristics and process characteristics that relate to cost reduction. In addressing cost impact of processes, the procurer must consider who will bear the responsibility for each development facet and how cost will be affected by tradeoff decisions. The procurer must also assess the "state" of each participant in the development process, including himself, and ask how deficiencies will affect cost. Specific questions that may be formulated include those of the type: Does the contractor have computer-aided processing? Can the equipment be made available locally for the contractor? Will troubleshooting tasks be involved? Does the contractor have an experienced JPA production team? How do I deal with poor quality input data? How much will it cost to improve the quality of the data?

Although dollar-amounts cannot be fixed to the answers of these questions, the general magnitude associated with many tradeoff choices appears to be estimable. Recognition of the factors involved is certainly a positive first step. These tradeoff factors can be grouped according to:

1. Those that can be targeted for elimination of their effects on cost variability.

2. Those that can be quantitatively measured and used to predict production or up-front costs.

3. Those that are not subject to elimination of quantitative measurement but that can be qualitatively assessed.

Future research efforts should yield results that are useful to the practitioner--both procurer and preparer--and they should focus on the type of questions indicated above. Grouping of the tradeoff factors into the three types noted above will provide some prioritization for these efforts.

Recommendations

1. Identify areas where BITE and ATE may be harmful to the troubleshooting technician as well as the cost tradeoffs for BITE and ATE.

2. Identify areas in the front-end analysis (e.g., the failure mode effects analysis and dependency analysis) that do not provide adequate troubleshooting data for development of troubleshooting JPAs.

3. Develop guidelines for JPA procurers that account for symmetry in electronic equipment.

4. Improve cost/effectiveness tradeoff guidelines for the user/data match.

5. Improve the methodology for quantifying the JPA cost impact elements.

6. Implement an education program for acquisition managers and procurement personnel that demonstrates the long-term life cycle cost effectiveness of the JPA methodology.

7. Develop criteria to reduce the variability of the attributes of procuring agencies.

8. Develop strategy that places burden on the contractor for an accurate cost estimate.

9. Develop guidelines for including work samples in procurement packages.

10. Improve state-of-the-art methods for defining and quantifying cost-format-performance relationships.

11. Develop guidelines for establishing a bidders' conference that can be used to increase the understanding of requirements and clarify customer uncertainty.

12. Develop guidelines that adequately reflect the separation of front-end costs from JPA production costs.

13. Develop guidelines that delineate the responsibiities for quality input data for the JPA development process.

14. Determine the relationship of LSA to the JPA development process and identify the JPA input data gaps.

15. Establish cost-effective guidelines for JPA validation/verification that address task sample size, user sample size, and availability of equipment.

16. Identify specific areas where production specifications are forcing increased volume and cost, and develop guidelines for improving the process.

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LIST OF ABBREVIATIONS AND ACRONYMS

ATE	Automated test equipment
BIT	Built-in test
BITE	Built-in test equipment
CATIPS	Computer-aided technical information preparation system
DARCOM	(Army) Material Readiness Command
EPICS	Enlisted Personnel Individualized Career System
FMEA	Failure mode effect analysis
FPJPA	Fully proceduralized job performance aid
ILS	Integrated logistics support
IPR	In process review
JPA	Job performance aid
LCC	Life cycle cost
LRU	Line replaceable unit
LSA	Logistic support analysis
LSAR	Logistic support analysis record
MAC	Maintenance allocation chart
MDC	Maintenance dependency chart
MRC	Maintenance requirement card
NAVPERSRANDCEN	Navy Personnel Research and Development Center
NSWSES	Naval Ship Weapon Systems Engineering Station
NTIPP	Navy technical information presentation program
NTIPS	Navy technical information presentation system
PAGES	Computer-based technical order assignment method
PIMO	Presentation of information for maintenance organization
POC	Point of contact
Q/A	Quality assurance
RFP	Request for proposal
RFQ	Request for quotation
SME	Subject matter expert
SPA	Skilled performance aid
SPO	System program office
SRU	Shop replaceable unit
TI	Technical information
TIM	Task identification matrix
TM	Technical manual
TRADOC	(Army) Training and Doctrine Command

APPENDIX

POST-CONFERENCE COMMENTS

POST-CONFERENCE COMMENTS

At the conclusion of the conference, participants were asked to identify the one JPA cost topic that they felt was either the most important or needed immediate attention. Four participants volunteered the following comments.

Reid P. Joyce

It seemed to me that much of the discussion dealt with the nuts and bolts of making JPAs and that we might have been able to address a number of issues that face the buyer, if we'd had a bit more time beyond that allocated to "presentations." It strikes me that what we were hearing was that several competent organizations have different--but maybe equally good--ways to build JPAs, and some of these differences have cost implications. The questions that I think we didn't deal with adequately though can have cost leverage implications that far outweigh the intercompany differences in JPA-building cost:

- Who does the front-end analysis?

- How should contractors and buyers deal with uncertainty in quality and quantity of front-end analysis data?

- If it's true that you can't closely estimate JPA cost until some kind of front-end analysis is done, how can you select a JPA contractor?

- If most JPA contractors can control quality pretty well, how do you choose the one who will ultimately give you the most maintenance performance per dollar?

- Can we ever have technical data acquisition managers who are permitted to care about maintenance performance per dollar and long-range cost of system ownership?

- Who would train such an acquisition manager, if the job included enough authority to apply the kind of wisdom he ought to have?

I have the feeling that all too often we "back into" a JPA-scoping effort by trying to meet an arbitrarily established budget, rather than truly fighting for a share of the system-development dollars that's commensurate with the JPAs' contribution to life cycle cost of the system. Until we can make that argument convincingly, we won't get the bucks, and we'll be chronically cutting corners and making compromises that we shouldn't have to make.

Fred L. Hart

In my opinion, the point brought out most often was that the procurement activity must be more knowledgeable in what options are available in the purchase of technical documentation. These options are available in the purchase of technical documentation. These options are in terms of the types and levels of presentation that are available and that may be procured to a set specification. The decisions made by the procuring activity must be made with full knowledge of the maintenance philosophy of the equipment/system and the level of personnel expected to maintain the equipment (both entry level and experienced personnel). The use and impact of this documentation on training must also be considered. Too often training tradeoffs are made without regard to the potential use of the equipment/system technical documentation. A corollary to the above is that the procurement activity must also take the time to consider the life cycle cost impacts of technical documentation.

Rosemarie J. Preidis

I wish we could have arrived at a consensus on the most influential factors that influence cost variability. We discussed many factors (e.g., design stability, customer direction, illustration and information density, task analysis). We should have inspected those factors in more detail to separate the high impact ones from the mediocre. We also should have delved more deeply into figuring out how to capture them quantitatively.

I think we established a good knowledge base from our collective inputs. However, it will need more massaging before definitive cost-estimation guidelines can be formulated. Hopefully your workshop proceedings overview will shed some light on the direction we should take to develop useful guidelines.

John G. Bean

I recommend development of a simple and usable cost estimating model. This requires two related tasks: first, algorithms to estimate the number of pages for various types of documents using various factors such as number of systems, units, modules, etc. (similar to the model developed by Rosemarie Preidis); and second, cost per page standards for each type of document. A very few types of documents could be considered at first. A limited number of cost per page categories should be established for each type.

Document Type	Cost-per-page Category	
1. Fully proceduralized JPA	1. Writing	(Hr/Pg)
2. Hybrid JPA	2. Illustrating	(Hr/Pg)
3. JPA	3. Typing/production	(Hr/Pg)
4. Job guide	4. Inspection	(Hr/Pg)
5. Maintenance	5. Validation	(Hr/Pg)
6. Flight	6. Material	($/Pg)
7. Operator		
8. Illustrated parts breakdown		
9. Overhaul		
10. Checklist		

It would be necessary to furnish a sample of each type of document, so it would be clear what is specified (page size, type size, single column/double column, etc.). To obtain accurate historical data, each contractor must establish a fairly elaborate accounting system in the cost-per-page categories in which to collect costs for each document type. It is possible to do this for a simple system. For a system such as the one described by Rosemarie, the necessary cost accounting system would be so elaborate and its costs so excessive that it does not appear feasible to me to collect so much detail.

Another important area for which work might continue is the methodology of making tradeoffs between JPAs and training. These tradeoffs are usually not considered during the logistics system design phase, yet, as EPICS has shown, there are considerable implications of being able to make the tradeoff studies effectively. The standards discussed above could be developed over a range of document types (FPJPA, JPA, conventional, commercial, data package, design package) to enable the necessary cost estimates to be made.

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